REPORT RESUMES

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NUCLEAR SCIENCE CURRICULUM PROJECT, PROJECT I, INSTRUCTIONAL SPECIFICATIONS.
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CULVER CITY UNIFIED SCHOOL DISTRICT, CALIF.
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ON THE PREMISE THAT A KNOWLEDGE OF NUCLEAR SCIENCE IS ESSENTIAL FOR INTELLIGENT DECISION-MAKING REGARDING ITS USES, THE NUCLEAR SCIENCE CURRICULUM PROJECT WAS DEVELOPED. ITS OBJECTIVE IS TO PROVIDE A PROGRAM THAT CAN BE EFFECTIVELY USED IN SCIENCE CLASSES TO PROVIDE AN UNDERSTANDING OF NUCLEAR SCIENCE AND ITS IMPACT ON SOCIETY. THOUGH TEACHER INSTITUTES HAD BEEN CONDUCTED TO PROVIDE NEW MATERIALS AND INSIGHTS, A LACK OF AN INCLUSIVE SOURCE OF INFORMATION ON CONCEPTS AND MATERIALS SEEMED TO HINDER IMPLEMENTATION OF INSTRUCTIONAL PROGRAMS. THIS PROJECT WAS ORGANIZED TO DEVELOP A SET OF INSTRUCTIONAL OBJECTIVES, EXPRESSED IN BEHAVIORAL TERMS, REGARDING NUCLEAR SCIENCE AND ITS IMPACT ON SOCIETY. THESE OBJECTIVES WERE DESIGNED AS MODULES THAT COULD BE INCLUDED WITHIN THE FRAMEWORK OF EXISTING SCIENCE AND SOCIAL SCIENCE COURSES. "NEED-TO-KNOW" ITEMS WERE DETERMINED FOR THE AVERAGE NON-SCIENCE ORIENTED HIGH SCHOOL GRADUATE, IN ORDER FOR HIM TO PERFORM AS A RESPONSIBLE CITIZEN. TWO TECHNIQUES EMPLOYED TO ACHIEVE PROJECT OBJECTIVES WERE (1) THE USE OF SYSTEMS TECHNIQUES FOR MISSION ANALYSIS AND DEFINITIONS, AND (2) THE USE OF BEHAVIORAL TERMS FOR INSTRUCTIONAL OBJECTIVES. THE DOCUMENT IS ORGANIZED INTO SECTIONS AS FOLLOWS--(1) FRAMEWORK, IDENTIFYING THE HIGHER ORDER BEHAVIORS AND PROVIDING AN OVER-ALL MATRIX WITHIN WHICH KNOWLEDGE, ATTITUDES, AND SKILLS CAN BE ORDERED, (2) SOCIAL ISSUES RELEVANT TO NUCLEAR TECHNOLOGY, ILLUSTRATING THE WAY EACH TERMINAL BEHAVIOR FROM THE FRAMEWORK COULD BE DEVELOPED, (3) MODULES OF INSTRUCTION, SHOWING HOW SCIENCE AND SOCIAL SCIENCE CONTENT AND DECISION-MAKING PROCESSES CAN BE STRUCTURED INTO LEARNING UNITS, (4) BEHAVIORALIZED SCIENCE DATA, GIVING A BREAKDOWN OF THE BASIC SCIENCE DATA INTO BEHAVIORAL TERMS--BEHAVIORAL OBJECTIVES, STIMULUS CUES, AND CRITERION TEST MEASURES, AND (5) BACKGROUND CONTENT, A COMPILATION OF THE "NEED TO KNOW" CONTENT IDENTIFIED BY THE NATURAL AND SOCIAL SCIENTISTS AS NECESSARY TO AN UNDERSTANDING OF THE SOCIO-SCIENTIFIC IMPLICATIONS OF TECHNICAL DISCOVERIES. (DH)

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NUCLEAR SCIENCE CURRICULUM PROJECT

PHASE I - INSTRUCTIONAL SPECIFICATIONS

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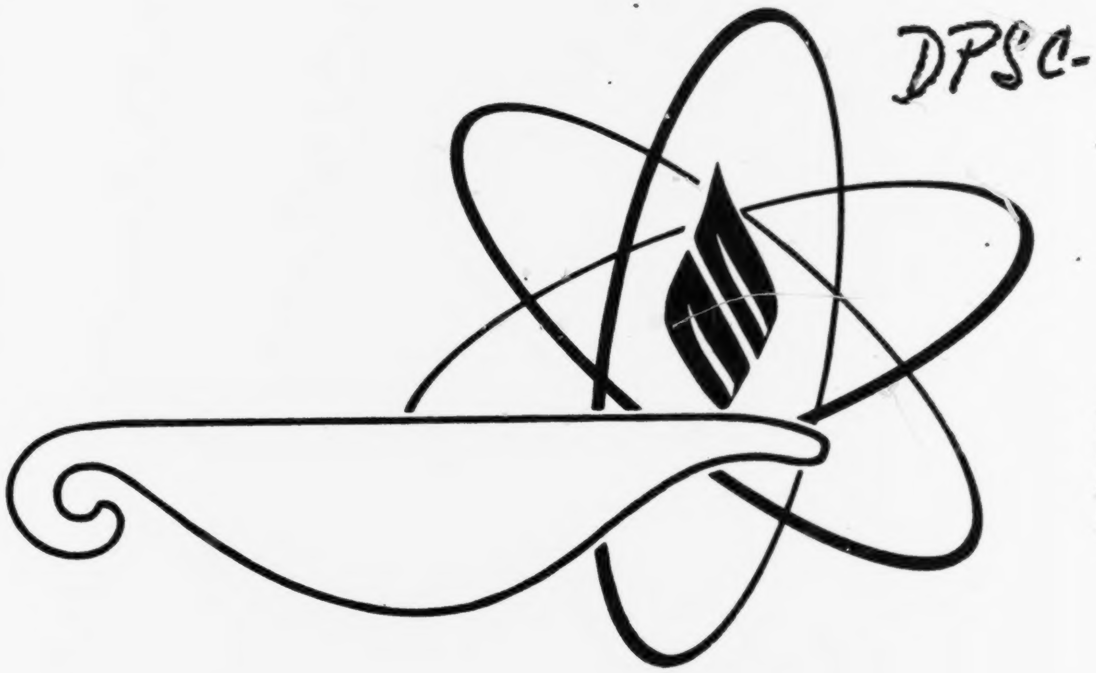

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NUCLEAR SCIENCE CURRICULUM PROJECT

PHASE I INSTRUCTIONAL SPECIFICATIONS

Prepared for submission to the
Board of Education
Culver City Unified School District
Culver City, California

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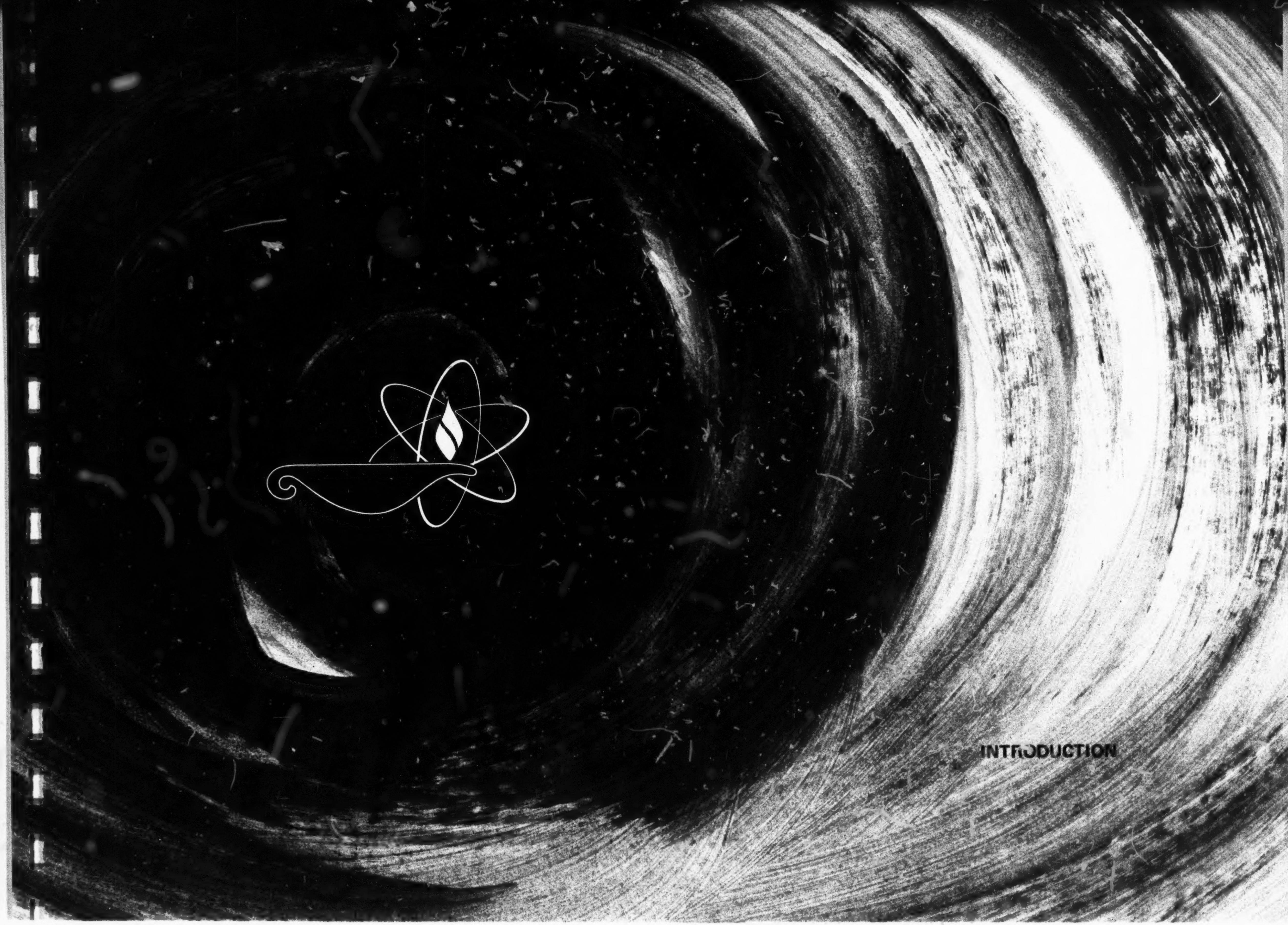
INTRODUCTION



The basic premise upon which the Nuclear Science Curriculum Project was developed gave recognition to the fact that, with the advent of the control of nuclear energy and the resulting effects on our society, it has become imperative to formulate and disseminate knowledge of radiation and its effects, in order for an informed citizenry to make reasonable decisions concerning the social consequences of nuclear science in their everyday lives. E. J. Brunenkant, of the United States Atomic Energy Commission, recently stated:

> "Nuclear energy is playing a vital role in the life of every man, woman, and child in the United States today. In the years ahead it will affect increasingly all the peoples of the earth. It is essential that all Americans gain an understanding of this vital force if they are to discharge thoughtfully their responsibilities as citizens and if they are to realize fully the myriad of benefits that nuclear energy offers them."

In a recent publication of the Atomic Energy Commission, Understanding the Atom, Lyman stated: "As citizens of a democracy, we are called upon to make decisions about the social implications of atomic energy. Few of us understand even the elementary principles underlying the release of atomic energy."

It has been estimated that technological knowledge has doubled in the last ten years, and is expected to redouble every three years henceforth. It is academic at this point, with the evidence at hand in our daily lives, to say that a need exists for the inclusion in the curriculum of nuclear science concepts and the resulting societal implications.

The Atomic Energy Commission has sponsored a number of summer institutes for presenting high school teachers with new materials and concepts in nuclear science. Though these institutes were quite successful, evidence from one study indicated that, due to a variety of problems such as the lack of an inclusive source of information on these concepts and materials, most teachers could not introduce a nuclear science curriculum to their students on a scale large enough to insure successful student interest and learning.

During the year 1965-1966, the Culver City Unified School District, with the cooperation of the California State Department of Education, formulated plans for the submission of a proposal to the United States Office of Education, Title III, Elementary and Secondary Education Act. The results of this study were then incorporated as part of the Nuclear Science Curriculum Project proposal.

Purpose of the Project

The primary objective of the Nuclear Science Curriculum Project was to develop a set of instructional objectives, expressed in behavioral terms, relating to nuclear science and its impact on society. The instructional objectives were developed for inclusion as modules within the framework of the existing courses in both the sciences and the social sciences. Derivation of the instructional objectives emphasized attitudes, knowledges, and skills based on real life requirements involving the socio-political and scientific implications of atomic energy. More specifically, the task was to determine the need-to-know items required of the average, non-science oriented high school graduate to perform as an informed citizen in the ever present and rapidly expanding nuclear society. To be an informed participant in our society today, and the society of tomorrow, requires the ability to understand the social, economic, political, and technological implications of the subject at hand. Stated with utmost simplicity, the end goal of this effort would be for the learner to possess the skills necessary to make rational and intelligent decisions based upon accurate knowledge and awareness, as opposed to decisions arrived at through fear emanating from ignorance.

Innovative Techniques

Recent developments in the state of the art in educational technology have demonstrated that it is not only feasible, but highly desirable, to design a course of instruction for the secondary program which embodies the simultaneous use of the latest techniques and principles leading to product development. During the past twenty years, there have been significant advances in many aspects of planning, development, and utilization of instructional materials and instructional strategies.

First, reliance on systems techniques provides a framework for the development of the educational mission and for the development of plans for its accomplishment. Second, reliance on task analysis techniques permits identification of objectives in terms of real-life performance needs leading to the specification of criteria for expressing course objectives in behavioral terms. Third, recognition that the changing needs of society and the rapid obsolescence of facts imposes a consequent demand that objectives be phrased in terms of decision-making processes and behavioral competencies which should result from instruction. Fourth, recognition that decisions regarding instructional media must rest on identified course behavioral objectives. Fifth, reliance on a systematic procedure for product development which, through a cyclic process, enables decisions to be made on the basis of empirical data rather than on techniques which rely on intuitive judgments.

The nature of the requirements for the Nuclear Science Curriculum Project dictated the use and application of those techniques and principles of product development appropriate to the various stages in the product development cycle. These stages, as identified by James Popham of the Southwest Regional Laboratory, are project formulation, instructional specifications, prototype item tryout, and product development.

The outcomes for the planning phase of the Project are those relating to the instructional specifications and encompass the following elements.

1. A defensible list of need-to-know knowledge, attitudes, and skills pertaining to nuclear science as identified by experts from natural science, social science, and industry.
2. An analysis of existing course content in the sciences and social sciences to determine where in the existing curriculum concepts relative to nuclear science are, or could be, taught and where developed behavioral objectives could be incorporated.
3. An analysis of existing instructional aids to identify and specify those most appropriate to the implementation of the design learning paths.
4. A statement of terminal and interim objectives, expressed in behavioral terms, appropriate for a high school graduate who may never have additional formal training in the area, but who needs to be an informed, contributing member of our society.

5. A series of performance tests and criterion measures to determine learner achievement of the developed behavioral objectives.

6. A preliminary statement of the design requirements for preparing and implementing instructional systems to achieve the behavioral objectives. This will include the organization of the terminal and interim objectives and measurement criteria into a sequence of learning steps or requirements.

7. A statement of parameters influencing the implementation of the objectives.

The final product resulting from the planning grant should be a designed "blueprint" for the solution to a problem. The postulation of an ideal program for nuclear science education will necessarily be based on what may be called a priori determinates. It is anticipated that the demonstrated worth and utility of the Project will be confirmed by insightfully planned and evaluated pilot studies and field tests and by subsequent materials development. These should allow for development and refinement of the design requirements for completing a full instructional system for the secondary schools.

Methods of Procedure

Two techniques, which may be characterized as innovative in modern curriculum development insofar as general practice is concerned, were employed to achieve Project objectives: (1) the use of systems techniques for mission analysis and definition, and (2) the stating of instructional objectives in behavioral terms. The successes of systematic attack on problems, first widely used in the aerospace industries and now being applied in many other areas, have had their influence upon many forward-looking thinkers in education. The technique, variously described as an engineering or systems approach, was employed by the Project to develop a detailed description of terminal learner behaviors. This approach is based on the predefinition of: (1) what is to be learned; (2) the required levels of terminal performance to be achieved by the learner; and (3) the design of instructional paths by which learners progress through successive steps leading to the attainment of the prestated objectives.

The Systems Approach is an organized technique for solving complex problems. Beginning with the identification and definition of the end product, it is a goal-centered approach. The Systems Approach requires an analysis of the total mission to be performed, and specifies a logical progression of critical steps and an interfacing of methods, techniques, and resources required for the accomplishment of the final objective.

As applied to education, the Systems Approach is an effective integration of techniques, procedures, content, and processes with the objective of specifying efficient, reliable and measurable learning systems. At the onset of the Project, the systems analysis techniques were applied to the Nuclear Science Curriculum Project, as indicated in the planning report presented to the Culver City Board of Education in March 1967.

The procedures employed by the school district's Project staff in the development of instructional objectives relied on the involvement and interaction of academic scholars from both social science and natural science disciplines, of classroom teachers, and of lay persons from industry, commerce, economics, and politics. Reliance on an interdisciplinary approach served to insure the widest possible identification of need-to-know information from science, technology, and social science relevant to achieving a detailed statement of educational objectives for the study of nuclear energy and its social implications.

The methods employed called for an engineering or systems approach to curriculum development by which detailed learning objectives are specified. Expert consultants assisted in the specification of the instructional paths leading to the achievement of each terminal behavioral objective. Culver City Unified School District subcontracted with the Special Projects Department of Xerox Education Division, New York, and the Bio-Atomic Foundation, North Hollywood, California, for these services.

Target Population

In the Nuclear Science Curriculum Project the definition of the student population to be served refers to: (1) the student population of the Culver City Unified School District, characterized by the following test data of the eleventh-grade class in 1965 Lorge-Thorndike Verbal Mean I. Q. 114.1; Iowa Tests of Educational Development, composite score, 57 percentile, 65 percent of whom enroll in institutions of higher learning and (2) all non-science oriented graduating seniors, regardless of geographical location and intelligence level, entering society as an informed and participating citizen.

Basic Assumptions

1. Through the utilization of the "systems approach," a complex curriculum problem could be efficiently analyzed and resolved.

2. The state of the art relating to behavioral psychology and specification of behavioral objectives was sufficiently advanced to be utilized in dealing with the complexity of behaviors in the cognitive and affective domains.

3. The technical expertise of Xerox Corporation and Bio-Atomic Foundation, the two subcontractors to the Project, would be sufficient to furnish the Nuclear Science Curriculum Project staff with relevant technical assistance.

4. The academic consultant task groups in science and social science would provide valid data deemed necessary for inclusion as content in the proposed curriculum.

5. All behavioral objectives, suggested interim objectives and/or learning paths expressed in writing upon culmination of the Project represent postulated or hypothesized items which must be field tested and validated.

6. Learning standards recommended for performance are assumed to be 90% of the learning demonstrating measurably 90% of the objectives or criterion tests postulated.

7. The conditions under which such performance occurs are those found in the typical instructional setting of today's high school classroom profile.

Definition of Terms

The following definitions were extracted from various sources written by Professors Robert E. Corrigan and Roger O. Kaufman, Educational Technologies Department, Chapman College, Garden Grove, California.

1. Systems Approach:

A system approach is an analytical method of problem solving. It essentially reduces a process for solutions of any specific problem into operational elements and details the performances of individuals, equipment, and facilities into a time sequence to achieve stated goals. The primary emphasis is upon what is to be achieved in defined performance terms. A process of iteration is used to integrate and interface all steps in the process.

In simplest terms, a system approach asks where you are going, spells out what has to be done to get there, specifies how you know you are there, and gives an exact control over the separate elements of the process.

2. System Iteration:

The analysis process whereby system analysts who are given mission objectives performance limits and constraints identify, classify, specify, check and (as necessary) reformulate system function and appropriate design criteria. The objective of system iteration techniques is system compatibility between system functions and engineering requirements in achieving stated system mission objectives.

3. Instructional System:

The sum total of all components in a learning situation which are combined in such a manner as to contribute individually and together to accomplish given, definable terminal performances (mission objectives).

4. Instructional System Approach:

The use of system methodology to design totally integrated, functional instructional systems. The instructional systems approach is a self-adjustive performance system. It is designed to achieve carefully established learning objectives for students who present the necessary prerequisite skills for entrance into the instructional sequence. It is based specifically on the predefinition of (1) what is to be learned, (2) the required levels of terminal or final proficiency to be achieved by learners, (3) the most appropriately designed sequence of instructional steps for learners to insure their success on each successive step leading to the attainment of the prestated terminal performance objective.

The total emphasis is the designed, predictable achievement of prestated terminal or final performance specifications representing only the relevant concepts, principles and techniques required for "knowing" or "doing" skills.

5. Behavioral Objectives:

Behavioral objectives are the terminal performance specifications for education and training which identify and specify the exact skills and knowledges that are required of the learner upon completion of the program. They can be likened to the performance specifications that we might place on a typewriter or a furnace—what it must do, under what conditions, and how we will evaluate it. Behavioral objectives provide for the design of instructional materials into a need-to-know design level in order that learner oriented, learner performance materials can be developed. Properly expressed, behavioral objectives fix specific performance responsibilities, hold performers accountable for achievement within defined boundaries, and allow both management and the performer(s) to evaluate what has been done.

6. Terminal Performance Objectives:

Terminal objectives are specific unambiguous descriptions of the most complex behaviors expected of students upon completion of instruction.

7. Interim Performance Objectives:

Each terminal performance objective is analyzed to derive interim objectives which will lead to achievement of the terminal performance objective. Criterion measures or test questions are stated for each objective. These provide measurement not only of learner achievement, but also, of materials and methods.

8. Learning Path:

Interim or specific objectives are analyzed to determine all relevant knowledge and skills which must be acquired by the learner to achieve interim or specific objectives. The final analysis results in the specification of learning steps, which represent all the cognitive and/or manipulative skills that the learner must achieve to build the stated terminal performance.

9. Criterion Tests:

Criterion tests are the vehicles by which we validate the appropriateness and utility of the instructional materials and instructional elements. The criterion test items are derived from the behavioral objectives, and are the means by which the instructional materials are evaluated and validated. The criterion test is not a behavior sample like traditional tests, but rather is a complete assessment of all of the behaviors required and taught.

Conclusions

1. It is reasonable to conclude that, with the utilization of the "systems approach," this project was analyzed more efficiently within the time constraints imposed upon all concerned. The use of flow charts, buy-off milestones, and specified goals for the project expressed in functional flow terms contributed to efficient culmination of this initial phase. Without such guides, it is reasonable to assume that the project staff and all other consultant interface relationships would have been difficult to resolve. The evolving complexities of this project in curriculum analysis, communications, and logistics were dealt with efficiently. Since this project represented one of the few attempts in this country whereby large industrial educational technology personnel interfaced with local educators in a "co-partner" venture on a complex problem, it is rewarding to analyze this attempt and see the satisfactory resolution of the problems encountered.

2. Although it was recognized in the beginning of this project that the societal implications of scientific literacy relating to nuclear science were complex in nature, it is reasonable to conclude that this project has certainly clarified the problem in specific terms which will assist further researchers on the same topic. Educational theory, at present, in regard to "need-to-know" learning for graduating high school seniors is still vague except in terms of requirements for college entrance knowledge substantially in the cognitive areas of re- call of facts and memorization of blocks of data. The NSCP staff, with the assistance of industrial expertise and academician input, exerted a concentrated effort to express the objectives of this project in terms of what the learner should be able to do or in perform- ance behavioral terms. The generation of the data to support such objectives required many hundreds of man hours on the part of all personnel concerned. Out of this effort a few subconclusions can be reached as follows:

   a. Present educational curriculum priorities are not sufficiently determined by criteria which allow such curriculum to be easily accepted as "need-to-know" for our societal purposes.

   b. There is more general agreement in the area of nuclear science than in the general area of social science. For this reason, it is difficult, if not impossible at the present time, to index specifically designated important nuclear concepts within societal con- ceptual schemes of a general nature. The affective areas of societal values and psychological relationships regarding nuclear science are still yet not researched enough to translate such data into specific performance behavior on the part of learners. The baffling dilemma confronting personnel was that, although intuitively and verbally such attitudes and values could be somewhat described, these objectives were only measurable over long periods of the learner's life or in societal settings beyond the domain of the educator. In such cases, the data necessary to support objectives of this nature was not extensive to bridge the behavioral levels that would bring closure to specific learn- ing paths.

   c. It was recognized that the "state-of-the-art" in behavorial psychology regarding the specification of educational objectives in performance terms could furnish the engineer- ing technology to this project necessary for the resolution of the problems identified in curriculum confrontation between nuclear science and social science. After completion of this initial phase of this project, it is reasonable to conclude that this project has contributed to the "state-of-the-art" itself by identifying seeming discrepancies in present theory and technology on the subject. There are still unresolved discrepancies among several present schools of thought on behavioral objectives. Advocates of the schools of thought related to Gagne and Piaget, Mager, Ofiesh, etc., have similarities and differences between them. The NSCP personnel tried to blend such modes into this project. Some of the differences have yet to be resolved.

RECOMMENDATIONS

These recommendations were obtained from logical and reasonable conclusions by an analysis of all personnel input related to the Nuclear Science Curriculum project and within the professional experiences of the Xerox staff.

1. A field test period should be established for the implementation of selected modules into the existing curriculum.

2. During the field test period a series of control groups and approaches should be implemented to provide the most accurate data.

3. All materials should be reviewed and revised for relevancy following the field tests. This revision of material should be performed by the teaching personnel under the direction of personnel who are systems oriented.

4. An ongoing program should be established for the development of a total instructional program related to the "Societal Implications of Nuclear Science."

5. Consideration should be given to the inclusion of the recommended nuclear science materials into a nontraditional process oriented course offering to determine the effectiveness in achieving content (science and social science) while developing learning processes.

6. A series of inservice workshops should be conducted for the development of instructional materials and media applicable to establishing behavioral objectives.

7. An inservice training program should be instituted for all teaching and administrative personnel to assure accurate and effective development and implementation of behaviorally oriented materials and programs.

8. The Systems Approach to the development of modules of instruction should be applied to all disciplines within the Culver City Unified School District.

THE NUCLEAR SCIENCE CURRICULUM PROJECT OVERVIEW

This document describes a list of defensible learner objectives deemed important if citizens are to function as informed participants with respect to developments involving nuclear science and society. The basis for selecting objectives was their contribution to the development within the learner, competencies and skills for dealing with issues of a personal and social nature involving the application of nuclear science and technology. Real-world problems which the nonscience oriented learner can be expected to face may be listed under the following categories: Consumer, Socio-political, Personal, and Vocational.

A list of objectives was identified so that developed competency skills would transcend the particular subject content selected for their attainment. Specific competency measures were then elaborated for each identified objective for the difficult task of assessment. Objectives and measures are intended to describe what the individual "does" and from this what he would "need-to-know" to achieve the identified terminal objective. Each of the various sections then constitutes a higher degree of specification toward attainment of each terminal behavior. Successful utilization of this product demands an understanding of the rationale and sequence of each of the sections.

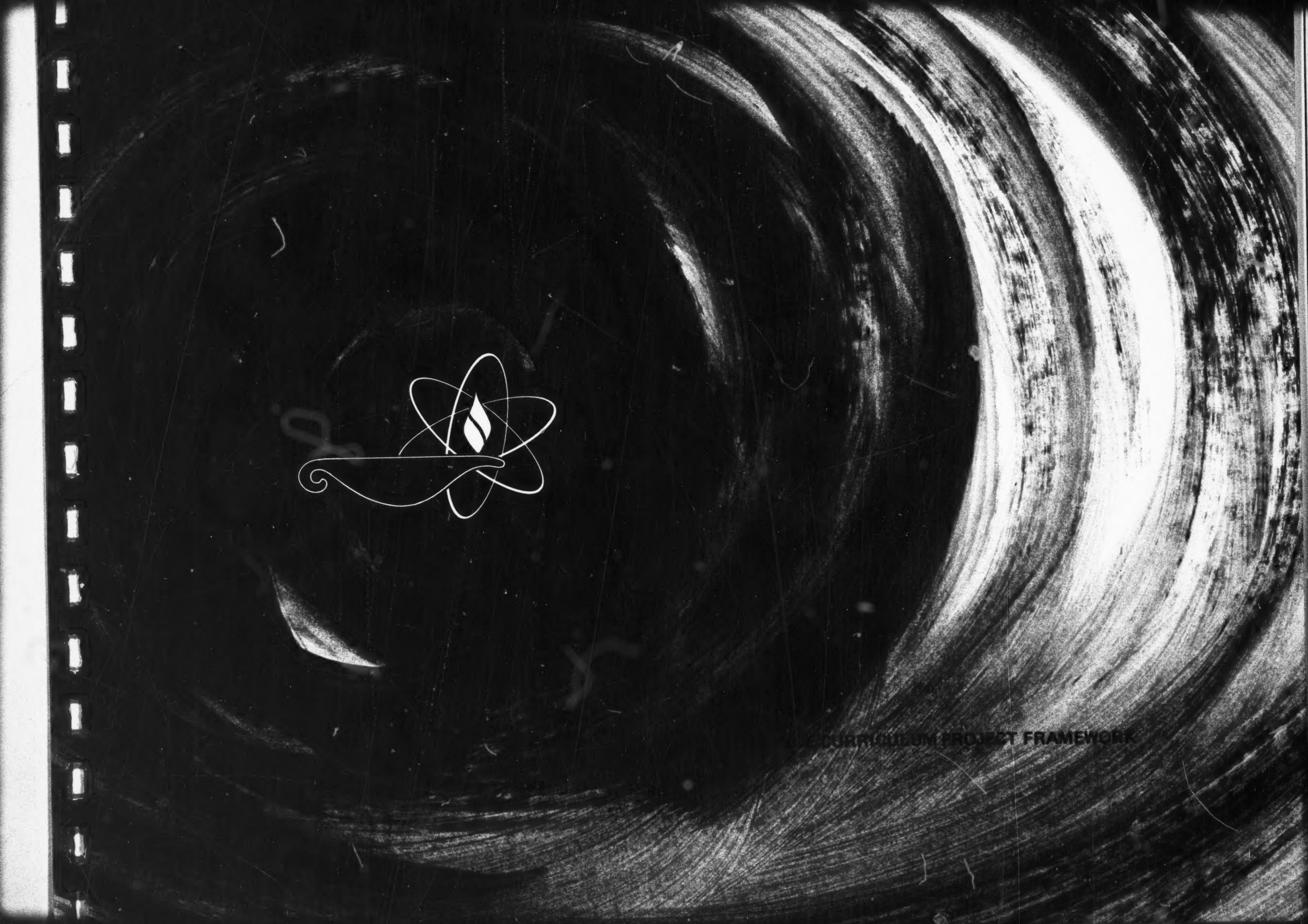
Section one is called the Framework which identifies the higher order behaviors. It was developed to provide an overall matrix within which the knowledges, attitudes, and skills identified as need-to-know by the Project staff and consultants can be ordered. It should be noted that there are two columns: "Instructional Objectives Hierarchy" and "Criterion Test Measures." The Instructional Objectives Hierarchy is a breakdown of the behaviors leading to the terminal objective identified in the framework. The Criterion Test Measures in the right-hand column are the performance measures which determine the learner's mastery of the behaviors suggested by the instructional objectives. The intent was to match each level of the instructional objectives hierarchy with a corresponding criterion test measure.

Section two, Social Issues Relevant to Nuclear Technology, is an example of the way each terminal behavior from the framework could be developed within a decision-making matrix. Terminal behavior no. 4.0 was used as a vehicle for this exemplification since it most obviously attends to broader social issues relevant to nuclear technology and weaponry than the other three. The goal is the mastery of rational decision-making processes within the context of relevant social problems and not primarily the inculcation of data. In this section, too, the attempt was to match a process in the left-hand column with a test measure in the right-hand column at every level of the hierarchy.

Section three, Modules of Instruction, demonstrates how science and social science content and decision-making processes can be constructed into designed learning units from the universe of data as contained in section five of the product. The first module, designed for a science class, demonstrates the interrelationship and hierarchic structure of basic atomic information needed by learners to become involved in the later modules of instruction. It should be noted that the interrelatedness of the module includes all aspects—science data, behavioral objectives, test measures, degree of proficiency expected, and so forth. The intent was to develop a self-contained instructional unit with each element within the unit well integrated with all other elements. The second module, designed for a social studies class, exemplifies how decision-making processes may be developed in the context of a unit involving technology in society. Again, from the universe of social science data shown in the last section of the product, a selection was made regarding the impact of nuclear technology on American power needs. The structure of the unit, however, rests on the decision-making processes hierarchy, and the criterion test measures are primarily concerned with the mastery of the processes more than the factual content, although the content is not unimportant.

Section four, Behavioralized Science Data, is a more explicit breakdown of the basic science data into behavioral terms—behavioral objectives, stimulus cues, and criterion test measures. This section contains the basic repertoire of science data considered need-to-know by the Academic and Teacher Consultants. It is, in a sense, the universe of data to be utilized in the development of other learning hierarchies and sequences in science and social studies.

Section five, Background Content, is a compilation of the need-to-know content identified by the natural and social scientists as being relevant to the development of an understanding of the socio-scientific implications of technological innovation. The compilation of this data was derived as a result of analyzing the social implications of nuclear applications to such fields as medicine, agriculture, and industry, and the socio-political implications related to the application of technology to solutions of problems such as environmental control, conservation of natural resources, and national security. Within the constraints of time, it was this body of content which formed the basis for the development of the experimental instructional modules included in the report and which would serve as resource material for the development of any further instructional modules.



CURRICULUM PROJECT FRAMEWORK

RATIONALE FOR FRAMEWORK

As perceived by the Nuclear Science Curriculum Project staff, the ultimate goal of the project is to prepare the student to behave as a responsible citizen in relation to the growth and well-being of himself and his family and the advancement of society. These behaviors will manifest themselves in the following specific categories:

1. selecting and using products which have been treated or processed in some way by radiation when the selection and use of such products offer distinct benefits and advantages;
2. availing himself, when advisable, of radiation methods and processes for medical diagnosis and treatment;
3. seeking to prepare himself for a career in nuclear fields or related fields when such positions relate to his interests and hold promise for the achievement of his goals;
4. supporting actively, where evidence indicates the need and advisability, measures for the expansion, control, and use of nuclear technology in advancing the goals of society and national defense.

From these categories, four terminal behaviors were identified:

1.0 When deciding between the selection of products and/or services which involve nuclear radiation processes, the learner shall judge the products and services on individual merits, not allowing fear, bias, or misconception of radiation to enter into the judgment.

2.0 When faced with the possible need for exposure to radiation for diagnostic, therapeutic, or other purposes, the learner shall be able to understand the physician's preliminary evaluation for the risks and benefits involved.

3.0 When making vocational plans or selections, the learner shall consider nuclear science and associated fields on an equal basis, judging all occupations on the basis of their relationship to his interests, abilities and goals, not allowing bias, fear, or misconceptions about radiation to enter into the judgment.

4.0 The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiate actions himself in regard to the development and/or use of nuclear technology.

With the assistance of system analysts, each objective was broken down by the consultants into a hierarchical series of behaviors which are considered the most central manifestations of that objective. The hierarchically-arranged behaviors, instructional objectives, and criterion measures follow.

Terminal Objective: 1.0 When deciding between the selection of products and/or services which involve nuclear radiation processes, the learner shall judge the products and services on individual merits, not allowing fear, bias, or misconceptions of radiation to enter into the judgment.

Instructional Objectives Hierarchy	Criterion Test Measures
1.0 When deciding between the selection of products and/or services which involve nuclear radiation processes, the learner shall judge the products and services on individual merits, not allowing fear, bias, or misconceptions of radiation to enter into the judgment.	Identify the situations below that you would avoid because of the danger involved. For those that you check, indicate why you would avoid them. ____ a. Wearing a wrist watch with a radium-dial ____ b. Using a bowling ball that has been irradiated to give it added durability ____ c. Eating a piece of meat that has been irradiated to make it possible to preserve it longer without refrigeration ____ d. Using an X-ray machine in a shoe store to see if a pair of shoes fit you properly ____ e. Eating fruit or grain that has been produced from seeds irradiated to improve a strain or to produce a new one ____ f. Stirring your coffee with a plastic spoon that has been irradiated to give added strength

Terminal Objective: 2.0 When faced with the possible need for exposure to radiation for diagnostic, therapeutic, or other purposes, the learner shall be able to understand the physician's preliminary evaluation for the risks and benefits involved.

Instructional Objectives Hierarchy	Criterion Test Measures

The learner shall:

2.1 identify some of the general types and uses of radiation techniques

Indicated by using the correct letter code whether or not-the following situations can be (D) Diagnosed, (T) Treated, (B) Both, or (N) Not diagnosed or treated by radiation techniques.

____ a. Broken bone

____ b. Tuberculosis

____ c. Thyroid condition

____ d. Cancer of the lung

____ e. Leukemia

____ f. Diabetes

Match each of the following diagnoses and treatment techniques with the types of problems they can help solve.

____ a. X-ray diagnosis

____ b. Ingestion of a radioisotope

____ c. External radiation from a radioisotope

1. Locating a spot on the lung
2. Broken bones
3. Thyroid condition
4. Destruction of cancerous cells

Instructional Objectives Hierarchy

Criterion Test Measures

Indicate which of the following symptoms represent the danger signals of cancer:

____ 1. a persistent, painless lump
____ 2. a sore that doesn't heal normally
____ 3. abnormal bleeding from any of the openings of the body
____ 4. a change in color and/or size of a mole or wart
____ 5. persistent indigestion
____ 6. persistent hoarseness or cough
____ 7. persistent change in the normal bowel habits
____ 8. pain associated with an injury
____ 9. persistent belching after a heavy meal
____ 10. chronic sleeplessness
____ 11. persistent twitching of a muscle

Instructional Objectives Hierarchy	Criterion Test Measures
The learner shall:	
2.2 understand his physician's evaluation of his medical history to determine the number and type of prior exposure	Which statement best describes the need for your physician to know your medical history in regard to the amount of exposure to radiation you have experienced? ____ a. Your doctor needs to know your history so that he can decide what setting to use on the X-ray machine to be able to get a "good picture." Different people, because of different densities of their tissue structure, require different degrees of X-ray penetration. Doctors keep records on these facts. ____ b. The effects of radiation on body tissue may be cumulative. He needs to know your history of exposure in order to more accurately assess the relative need versus the risk involved. ____ c. It is just good practice for a physician to know your medical history. There is no reason for him to be concerned about your particular history of exposure to radiation because if you need an X-ray you need it. He doesn't have much choice about whether or not to take it. True or False? ____ A chest X-ray is one of the best means for early detection of lung cancer, therefore, everyone should routinely receive a chest X-ray about once each month.

Instructional Objectives Hierarchy

2.3 understand his physician's evaluation of the radiation processes for contributing to the solution of the problem

2.3.1 compare the uses of radiation techniques related to what needs to be done to determine the relative advantages of each

2.3.2 understand the dangers and benefits involved in the proposed techniques as identified by his physician and weigh them against the criticality of what needs to be done

2.3.3 discuss with his physician the need for consultation with specialists when the exposure constitutes a high level of hazard.

Criterion Test Measures

What are the two basic factors you and your physician must consider in deciding between two courses of action, one involving radiation techniques, for diagnosing or treating a medical problem?

a. (the need, or the benefit to be gained)

b. (the risks involved)

If a radiation treatment or diagnosis proposed by your doctor represents a high degree of hazard to you:
(CHECK THE STATEMENT BELOW THAT IN YOUR OPINION BEST COMPLETES THE STATEMENT ABOVE)

____ a. I should accept his judgment unquestioningly since he is qualified to make such decisions.

____ b. I should tell him I'll decide later and then go to another doctor to get a second evaluation.

____ c. I should ask him about the advisability of consulting with another qualified physician to get an independent verification of his proposal.

Are the following statements true or false?

____ a. The yellow pages of the telephone book is a good source of names of qualified physicians who can be relied upon.

____ b. The government exerts sufficient control over radiation techniques that I don't have to worry about being treated by a quack or a registered physician who is not sufficiently skilled in the use of the techniques.

Terminal Objective: 3.0 When making vocational plans or selections, the learner shall consider nuclear science and associated fields on an equal basis, judging all occupations on the basis of their relationship to his interests, abilities and goals, not allowing bias, fear, or misconceptions about radiation to enter into the judgment.

Instructional Objectives Hierarchy	Criterion Test Measures
The learner shall:	True or False:
3.1 identify employment opportunities and trends within nuclear science fields and related occupations;	____ a. Job opportunities in nuclear science fields will increase rapidly over the next 10-20 years as new generating and desalinization plants, and the like, are built. They will then level out as enough plants are built and the occupations are saturated with workers.
3.2 Identify educational or training requirements within nuclear science fields and related occupations;	____ b. Occupations in the nuclear science fields are not limited to professional and semi-professional (technical) jobs. There will be places for skilled and semi-skilled workers as well.
3.3 evaluate occupational environment and job requirements and characteristics within nuclear science fields and related occupations;	____ c. Because of the highly technical nature of nuclear science occupations and the need for highly intelligent workers, jobs in these occupations will require a minimum of four years of college and a very critical screening of applicants.
3.4 match occupational requirements and characteristics with his own interests, abilities and goals.	Work in a nuclear power generating plant is less desirable than the same kind of work in a conventional plant because: ____ a. The working conditions would be dirtier ____ b. The physical dangers would be greater because of radiation

Instructional Objectives Hierarchy	Criterion Test Measures

Indicate which of the sources in Column II you would go to for the kind of information listed in Column I. List only the best sources.

Column I

____ a. Indications of the trends in occupational opportunities in nuclear science fields

____ b. Information on the specific kinds of jobs available in nuclear science in your area

____ c. Specific information about the amount of education and/or training required to qualify for a specific kind of job

____ d. Knowledge of the physical qualifications for a specific kind of job

____ e. Knowledge about the working conditions under which a specific job is performed

____ f. Information about the safety measures employed to protect the worker

____ g. Information about the rate of pay for work in a nuclear science job as compared to the same kind of job in a non-nuclear occupation

Column II

1. Dictionary of Occupational Titles
2. Your local newspaper
3. State employment offices
4. Private employment agencies
5. The company employment office where the job is located
6. Interview with someone in the field
7. Government publications on the specific application of the technology
8. Visit to the type of facility in which employment is contemplated

Terminal Objective: 4.0 The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiate actions himself in regard to the development and/or use of nuclear technology.

Instructional Objectives Hierarchy	Criterion Test Measures
The learner shall:	
4.1 seek and evaluate materials pertinent to the particular issue, problem, or proposal;	When given the community problem described below, the learner shall seek out authoritative, reliable, and relevant data on the basis of the criteria established in the learning experiences. Problem: A community organization called "Operation Poison Food" has been organized to prevent the use of foods which have been pasteurized by irradiation processes given free by the federal government in the public school lunch program. The group argues that the foods are dangerous because those who eat it could be irradiated, thus resulting in cancer, irritations, and other serious debilities. The group has paid for a number of advertisements in the community newspaper outlining the purported dangers, and have called for action. Several prominent people in the community have given their support to the action group.
4.1.1 locate sources of information from both producers and distributors of information;	Given (in Column I) the issue above, as well as two other issues (not related to the above but generally related to nuclear technology), the learner must select those agencies or outlets that would have the most information regarding the issue at hand, and thereby eliminate sources of information more related to the other issues.

(continued on following page)

Instructional Objectives Hierarchy	Criterion Test Measures
	Column I a. Construction of nuclear reactor b. Resumption of atmospheric testing of nuclear bombs c. Use of irradiated foods Column II 1. Atomic Energy Commission 2. American Nuclear Society 3. Department of Agriculture 4. Department of Defense 5. Electric Energy Institute 6. University nuclear biologist 7. Local physician specializing in radiology 8. OPF newsletter 9. Local newspaper

<table>
<tr><th colspan="2">Instructional Objectives Hierarchy</th><th>Criterion Test Measures</th></tr>
<tr><td>4.1.1.1</td><td>realize that information produced is technical or nontechnical and that several organizations, including governmental organizations, may be attempting to influence his opinions;</td><td>The learner will then categorize each of the information sources in Column II into technical, nontechnical, public and private groupings. He will then select the three best sources (AEC, Dept. of Agriculture, and university nuclear biologists or radiologists).</td></tr>
<tr><td>4.1.1.2</td><td>know the major sources of information from governmental, private non-profit agencies, private profit agencies, and publications;</td><td>The learner shall state from each source the degree of vested interest and therefore its attempt to positively influence him to its point of view. From the following list the learner shall match the agency which would have the greatest interest in influencing his opinion relative to the given issue and the reason they would do so.
<table>
<tr><th>Agency</th><th>Reason</th></tr>
<tr><td>A.E.C.</td><td>Profits</td></tr>
<tr><td>E.E.I.</td><td>Patriotism</td></tr>
<tr><td>Etc.</td><td>Etc.</td></tr>
</table></td></tr>
<tr><td>4.1.2</td><td>acquire the materials from a variety of sources;</td><td>The learner will indicate, for each type of information in Column I, from which source(s) listed in Column II he would most likely find it.</td></tr>
</table>

(continued on following page)

Instructional Objectives Hierarchy	Criterion Test Measures

Column I

a. Facts about irradiated foods

b. Fallacies about irradiated foods

c. Arguments for the use of food in schools

d. Arguments against the use of food in schools

e. Facts about radiation hazards and controls

Column II

1. Atomic Energy Commission
2. Department of Agriculture
3. Department of Defense
4. Local newspapers
5. Newsletter of OPF
6. Available nuclear physicist
7. Textbook on radiation
8. School authorities who accepted government offer
9. Local librarian

List in order of the degree issues of authoritativeness, given the indicated issue, of the following.

Issue	Authorities
1.	1.
2.	2.
3.	3.

Instructional Objectives Hierarchy	Criterion Test Measures
4.1.2.1 know where information from each source is located or how it is to be acquired;	The learner will then describe, by labeling each source, the means by which he would acquire the information from the following selections: a. Interview of pro, con, and neutral people; b. Letter writing; c. News articles; d. Library procedures.
4.1.2.2 know the procedures for acquiring the information;	He will only be allowed to select one acquiring technique for each source, even though multiple techniques may be used.
4.1.3 judge the materials for authority, reliability and relevance to the issue under consideration;	The learner will then list and apply the criteria for judging the reliability, authority, and relevance of acquired materials to the issue at hand.
4.1.3.1 evaluate the authoritativeness of sources and/or spokesmen; known that: a. it varies with training and experience; b. it varies with personnel and institutional goals and interests (i.e., vested interests);	He will isolate and list separately from the following list the characteristics of an authoritative source: a. Written by well-trained, experienced personnel b. Written by those he feels are truthful, honest, well-known, political (labor, business, religious, etc.) leaders c. Written by those who stood to gain something by the acceptance or rejection of the proposal to use irradiated foods in the schools

Instructional Objectives Hierarchy	Criterion Test Measures
c. an authority in one field may not be an authority in another. In those cases where an authority is speaking or writing out of his field what he is commenting on must be analyzed closely to determine its accuracy for the subject or the degree of manipulation he intends by posing as an authority;	d. Written by those with nothing to gain by the acceptance of the proposal e. Written by well-known experts in other fields not directly related to radiation science (scientists, business men, labor leaders, government officials, etc.), but who are vitally concerned with the issue f. Written by a college professor expert in radiation science g. Written by the local doctor who heads OPF h. Written by a government expert on radiation. He will then separate the sources into three categories determined by the degree of authoritativeness from the most disintered (a, d, and b), somewhat interested (b and r) to those most interested (c, e, and g). He will list the criteria for reliability, and discriminate between reliable and less reliable authoritative sources previously identified. He will isolate and list separately from the following list the criteria for reliability a. Lacks factual evidence but is logical in argument b. Feels as if it is the correct answer c. Supports the position of the community leaders d. Is technical and factual e. Is written by a reputable scholar working for the government.

Instructional Objectives Hierarchy

Criterion Test Measures

f. Is written by an expert from the food company which will supply the food

g. Is an editorial

h. Is written by a scholar working in the radiation science department

i. Is written by a local minister (mayor, principal, labor leader, etc.)

j. Is written by an unknown working for the Atomic Energy Commission

He labels (A) for Authoritative or (U) for Unauthoritative or suspect for the following sources of information, all of which contain information about irradiated foods

____ a. Local newspaper article by the chairman of OPF

____ b. Scientific American

____ c. Booklet proposed by the Atomic Energy Commission

____ d. Booklet and technical papers prepared by special staff at the Department of Agriculture

____ e. Newsletter from OPF

____ f. Letter to parents from the superintendent of schools

Given the three synopses of the articles below, with their sources identified, the learner will rate (A), (B), (C), those which are most to least relevant and needed for his decision making responsibilities in terms of the issue at hand.

Instructional Objectives Hierarchy	Criterion Test Measures
	Article I: Scientific American, "Pasteurization and Sterilization of Food Items Through Irradiation"
	This article explains the simple processes used to irradiate food, dosages required to pasteurize and sterilize; where irradiation is used in other industries; and the results of several experiments.
	Article II: Atomic Energy Commission, "Nuclear Science and Life"
	This article explains general uses of nuclear science and some of its applications for mankind's future.
	Article III: Bulletin of Atomic Scientists, "Radiation Techniques"
	This article explains the use of radiation in tracer technology; measuring; food and other consumer products improvement; and similar uses.
	Given the three positions below regarding the issue, the learner will critique each in light of the evidence gathered from authoritative sources. He will identify by labeling each as (A) incomplete factually, (B) depends too heavily on biased or emotional material, or (C) ignores evidence for ideological reasons; and states the reason for his choice.
	Position I: "If God meant man to have these new-fangled ways, he would have automatically provided us with them. This 'thing' they want to put in our schools is the work of the devil and is obviously one more attempt of the progressive educators to ruin our children."

Instructional Objectives Hierarchy

Criterion Test Measures

Position II: "The use of irradiated food will cause cancer, cell mutations, and other horrible diseases too terrible to even mention. Our children must not be exposed to this danger. The Mayor, Reverend Jones, and Mr. Daily of our newspaper, and other leaders of OPF have clearly identified the danger. Now it is up to us to prevent it."

Position III: "I'm not sure whether I want the food used in school or not. I have heard that using the food could cause my son to have cancer and I certainly don't want that. I also know that at work they use some sort of radiation to find leaks in the oil pipes. If its safe to use at work, maybe its safe to use at school, but i will not support using the food unless I know for sure that it is absolutely safe."

Given the three choices of action below regarding the issue, the learner will first support one, then the other, on both factual and emotional grounds. He will also outline briefly his own position. (This is a role-playing situation in which the learner is required to change set.) He will finally critique each position, including his own, on the basis of data sufficiency, emotionalism, tested interest and premature assumptions.

Choice I: Support the use of irradiated food on the basis that the schools and government would not allow anything bad to happen.

Choice II: Oppose the use of irradated food because of the dangers involved and the feeling that someone sinister is attempting to "test" some wild idea in the community.

Instructional Objectives Hierarchy	Criterion Test Measures
	Choice III: Neither support nor oppose the proposal to use irradiated food because what is known about the horror of atomic weapons and radiation from them makes the OPF's evidence seem valid enough, but the school and government people supporting the idea couldn't really do anything to hurt the children. Let others decide. Choice IV: The learner's own outline.
4.1.4 form tentative conclusions on the basis of the data gathered regarding the issue, problem, or proposal; 4.1.4.1 resist external pressure—political psychological, propangandistic, etc.—which may preclude further investigation; 4.1.4.2 realize that limited data may have been collected which may not give a complete picture; 4.1.4.3 realize that all sides of the issue may not have been identified or explored;	The learner will evaluate the conclusions of three community leaders below regarding the issue of irradiated food in the schools on the basis of their authoritativeness, reliability, and relevancy of their arguments regarding the issue. He will identify the weaknesses of each argument on the basis of their (A) not being able to resist external pressure from influential figures, (B) not including, ignoring or not knowing relevant data, and (C) not allowing for relevant arguments from the opposition. He will then state his own tentative conclusion regarding the issue. Conclusion I: We must allow the schools to use irradiated foods and forget the fear-mongering argument of the OPF. I have personally talked to our superintendent, who said that he is not worried at all about the food—and he has a child of his own in school. I also heard that the government was involved, and I'm sure the President and my Congressman wouldn't let anything happen. Besides, those guys in OPF are crackpots who really don't care about the issue at all but just want their names in the paper.

Instructional Objectives Hierarchy		Criterion Test Measures
		Conclusion II: I know for sure that this attempt to put irradiated food in our schools is a trick of anti-religious, communist-type people who are trying to influence our childrens' minds. OPF has issued a fact sheet which stated these factors: people in Japan are still dying from radiation let out by the atomic bomb; scientists working with reactors wear little badges that tell them when to get away before they get irradiated; genes in hamsters have been destroyed by radiation; and so on. The evidence is clear and can only make one come to this conclusion: Keep that dangerous food away from our children.
		Conclusion III: There is no question that we are making great strides forward in science—look at the radio, the auto, the airplane, a computer—but all of these scientific gains were developed slowly, carefully, and with due consideration of people's lives and health. The scheme to give our kids radiated food does not take these same things into consideration. So, I'm not against progress, but neither do I want to be a guinea pig. I read in the newspaper that more radiation would be used on the food than an X-ray machine, and my doctor once warned Bruce about getting too many X-rays. These school people who told us about the food being absolutely safe and couldn't possibly radiate our kids ignored facts about X-rays and other radiation. I say, no irradiated food in the schools.
4.2	evaluate the issue, problem, or proposal on the basis of relevant data to determine the potential advantages or disadvantages and then formulate a course of action;	Given the proposition below for solving the problem upon which he might potentially vote, the learner will compare the proposed advantages and disadvantages of the proposed change in relationship to the empirical evidence; analyze the potential social dislocations which might result; recognize irrational arguments regarding the proposition by comparing fact and fallacy; compare the proposed change with previous changes; and finally defend his own decision to support or reject the proposal on the basis of the facts which have been identified.

Instructional Objectives Hierarchy	Criterion Test Measures
	Proposition for Resolving the Poison Food Scheme for Our Schools. Public Vote Asked For. The members and officials of Operation Poison Food which was organized to prevent the use of dangerous irradiated food in our schools, now ask for a decision from the people. We are sure when you read the facts below that you will support us. We oppose the use of irradiated foods for the following reasons: a. Radiation is not well understood, and is dangerous to life and health. By allowing our children to eat such food we are exposing them to cancer, mutation, and other debilities. b. It will bring more governmental control over local affairs from both the state and federal levels. c. Economically, no benefit can come from using foods or products which have been irradiated; as a matter of fact, it may actually hurt economic development. d. Finally, we feel that the way we want to live and the things we want our children to know should not be dictated by outsiders, or the so-called "professional educator"; or schools should do what we want them to.

Instructional Objectives Hierarchy	Criterion Test Measures
4.2.1 determine the potential dangers or benefits to life and property;	Given the following list of notions regarding the utilization of irradiated foods and products, the learner will (A) separate out those factors which demonstrate the utility of radiation techniques in improving quality and quantity of food and products; (B) separate out the fallacies connected with the use of radiation to process food and products, and match them with the factual evidence which demonstrates their fallaciousness; and (C) compare the safety factor of radiation techniques with other technological advances.
4.2.1.1 categorize the stated dangers of the issue, problem, or proposal and match them against the data collected;	Facts and Fallacies (Regarding Agricultural and Industrial Uses of Radiation) a. Radiated products continue to be radioactive and can irradiate people eating or using them. b. Radiated food can have some discoloring. c. Radiation can only be used to harm or kill, and not for socially productive ends. d. Radiation of some products increases their strength. e. Radiation of foods can kill entirely or reduce significantly the disease-causing agents in them. f. Radiation of certain seeds and vegetables can improve their quality and quantity through controlled mutations. g. Radiation can be used to control weeds and insects harmful to agriculture. h. Use of radioactive isotopes is the same as X-ray machines.

Instructional Objectives Hierarchy	Criterion Test Measures	
	i. Radiation techniques can be employed by industry to measure thickness of products and wear spots.	
	j. Eating or using foods or products processed by radiation techniques will cause harmful mutations.	
	k. Radiation is never dangerous.	
4.2.1.2 categorize the stated benefits and match them against the data collected;	Fallacies	Truth
	1. Radiated Products continue to be radioactive.	(1) Food and products never become radioactive due to the techniques employed.
	2. Radiation is only used to harm and kill.	(2) Radiation cures disease, has tracer and isotopic uses, and accomplishes many socially useful purposes.
	3. Use of radiation to process food and products is the same as an X-ray.	(3) Different types of radiation sources are used to process food and products.
	4. Eating or using foods or products processed by radiation will cause mutations.	(4) Since the foods and products are not radioactive, they cannot cause mutations.
	5. Radiation is never dangerous.	(5) Continued exposure to radiation sources, not irradiated foods or products, can cause severe damage and even death.

Instructional Objectives Hierarchy	Criterion Test Measures
4.2.2 determine the potential costs—social, economic, political—of the issue, problem, or proposal in comparison with current practices, and make a decision to act;	The learner will state in writing how the utilization of radiation techniques will affect social, political, and economic life in his community, and compare this with traditional ways, which will include at least the following points a. Political effects: Government control and regulation of safety factors in processing plants tends to grant more decision-making prerogatives to state and federal governments at the expense of local businesses, but this intrusion of the government can be accepted, when balanced against the need to protect life and property b. Economic effects: Industrial and agricultural uses of radiation techniques are varied and great: tracers, ionizing processes, gauging, weed and insect control; new plant species evolved; and similar examples demonstrate that not only are there diverse uses for radiation techniques, but that the techniques improve the quality and quantity of the food and products we use. c. Social effects: The use of radiation techniques by industry and agriculture produce goods that will be found in every household in America. Plastic goods that have been hardened through radiation are now found in supermarkets. Gasoline, which has minute amounts of radioactive isotopes in it to follow the flow pattern as it is converted, is found in gasoline stations. Thus far, irradiated foods are not found in large quantities in markets, but the government, through DOD and AEC, is sponsoring huge experiments. Irradiated foods will last, in sealed packages, for long periods of time, and need no refrigeration. Radiation has been used most successfully by farmers to improve crops, produce new breeds, control insects and the like

Instructional Objectives Hierarchy	Criterion Test Measures
	Other products so processed are also in use. What is happening to society as a result of this is largely unrecognized by them, but it has already produced foods and products of better quality, in more quantity, and quickly. Cost will come down. Health will improve. Insects will be controlled.
4.2.2.1 compare the relative cost of change with the established pattern and or procedure;	The learner will compare the advantages of irradiated food with traditionally preserved food being used in his school presently, including the following advantages: longer lasting, germ free, greater variety. Then he will compare the cost of change, and conclude that the use of irradiated foods and products decreases the costs of production.
4.2.3 know the comparative statistics between other technological inventions or innovations now generally accepted as both necessary and worthwhile (e.g., the auto) and nuclear science developments;	The learner will be given statistical evidence of deaths from autos, trains, and planes in the last twenty years, along with the same statistics for employment of radiation, including experimental use. He will construct a graph to show statistical comparisons and: (A) State in writing why the statistical information is unfair; (B) Identify how governmental controls and regulations in all categories have improved their safety; and (C) Draw the conclusion that controlled radiation techniques, utilized food and product processing, are just as safe, if not safer, than other now-accepted technological innovations.
	The learner will describe in writing the typical techniques used in industry and agriculture, and give at least one example of their applications; included must be information about radioisotopes, gauging, radiography, and tracers.

Instructional Objectives Hierarchy	Criterion Test Measures
4.2.3.1 evaluate the impact of the issue, problem, or proposal on the social aspects of our culture (how will it affect people and institutions) and the degree to which the change will interface with other elements of the society;	The learner will select from the following list those kinds of industries, now or potential, utilizing radiation techniques as part of their processing procedures a. Food storage industry b. Pipe industry c. Oil industry d. Plastics industry e. Fishing industry f. Farming industry The learner will select and categorize from the following list those applications of radioisotopes under the headings: Tracers, Radiation Affects Materials, Materials Affect Radiation, and Radiation Has Energy. a. Flow measure b. Catalysis c. Fiber modification d. Power source e. Density gauges f. Radiography

Instructional Objectives Hierarchy		Criterion Test Measures
4.3	compare the proposed with appropriate historical analogies relative to technological innovation and their impact as well as present trends in social, political, and economic areas as they are affected by technological change;	The learner will analyze emotional and irrational responses to technological innovations by comparing the attitudes, misconceptions, and emotionalism of OPF with the reaction to the introduction of textile machinery in England in the early 19th century (i.e., the Luddite reaction).
4.3.1	decide a course of action by determining the answers to the following questions: a. How serious is the situation (what is the need)? b. What alternatives are open? c. What authorities support or oppose the issue, problem, or proposal? d. What position does the evidence support?	The learner will collect and label all positive and negative statements and facts regarding the use of irradiated foods in the school, compare them with the empirical evidence, and then answer the questions below: a. Why change the present system? b. What happens if just refrigerators are used? c. What objective authorities support or oppose the change? d. What do the objective facts demonstrate regarding the supporting and opposing arguments? The learner will then make a written summary of his position which demonstrates: (A) Disassociation form fallacies; (B) Dependency on facts; (C) Willingness to withhold judgement; (D) Recognition of emotions and propagandistic appeals; and (E) A decision as to his own personal involvement to effect a decision.

Instructional Objectives Hierarchy	Criterion Test Measures
	After the learner has completed the instructional sequence presented above, he will then be presented an entirely different social issue involving technological innovation (nuclear or non-nuclear). He will be required to follow the same processes he mastered in investigating the issue in the learning design. Criteria for judging learner performance are the same as those identified in the materials above. (In this segment the instructor is given greater options and decision making.)

SOCIAL ISSUES RELEVANT TO NUCLEAR TECHNOLOGY

ELECTRIC POWER AND NUCLEAR ENERGY

Terminal Objective: 4.0 The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiate actions himself in regard to the development and/or use of nuclear technology.

Instructional Objectives Hierarchy	Criterion Test Measures
The learner shall:	
4.1 seek and evaluate materials pertinent to the particular issue, problem, or proposal;	When given the two proposals below, regarding an issue on nuclear technology (the building of a nuclear reactor in his community and the reintroduction of nuclear bomb testing, in this example), the learner shall seek out authoritative, reliable, and relevant data on the basis of the criteria established in the learning experiences. Nuclear Power Plant Proposal 1. Nuclear power plants are dangerous and unnecessary. They are dangerous because they could explode like an atomic bomb and kill millions of people. They could emit radiation throughout the community and all would die unknowingly. They are unnecessary because, since the old ways have worked for us up to now, they will continue to work. Therefore, do not allow one to be built. Proposal 2. Nuclear power plants are both necessary and not dangerous. Federal and state controls make reactor plants safer than other power generating plants. There have been no major accidents involving the atomic aspects of power production. Additionally, traditional fuels are running out while our need for power expands. Nuclear power will supply limitless power for all time. Therefore, build the power plant.

Instructional Objectives Hierarchy

Criterion Test Measures

Atmospheric Testing

Proposal 1. The enemy is secretly testing weapons in the air (probably outer space) and is building up his arsenal with super atomic weapons. If the USA is to continue and deter the enemy it is necessary for us to start testing. We can get a clean bomb and therefore reduce air pollution, at the same time we build super weapons for our self defense. Thus, start testing again.

Proposal 2. Atmospheric testing will produce ever-increasing amounts of radioactive contamination, which will not only cause death, disease, and mutation to human, animal, and plant life now, but due to the half-lives of the contaminants, future generations as well. There is not scientific evidence that the enemy has started testing—our equipment would tell us. The dangers involved in testing are much greater than in not testing. Don't start testing again.

4.1.1 locate sources of information from both producers and distributors of information;

In Column I below are listed two issues about which the learner must make a decision. In Column II is a list of agencies which distribute information about the use of nuclear technology and nuclear strategies. The learner must select those agencies having information, biased or not, about the issues in Column I.

Column I

a. Construction of a nuclear reactor in the community
b. Resumption of atmospheric nuclear bomb testing

Column II

1. Atomic Energy Commission
2. American Nuclear Society
3. Committee for a Sane Nuclear Policy

Instructional Objectives Hierarchy	Criterion Test Measures
	Column I Column II 4. Woman's Strike for Peace 5. Defense Department 6. John Birch Society 7. Local Power Company 8. Department of Agriculture 9. International Atomic Energy Agency The learner will then categorize each of the information sources in Column II into technical, nontechnical, public and private groupings. He will then select four sources, which he prejudges will be most useful, from each category.
4.1.1.1 realize that information is produced which is technical or nontechnical, and that several organizations, including governmental organizations, may be attempting to influence his opinions;	

Instructional Objectives Hierarchy		Criterion Test Measures
4.1.1.2	know the major sources of information from governmental, private non-profit agencies, private profit agencies, and publications;	
4.2	acquire the materials from a variety of sources;	The learner indicates, for each type of information listed in the first column, where he would most likely acquire it.
4.1.2.1	know where information from each source is located, or how it is to be acquired;	
4.1.2.2	know the procedures for acquiring the information;	

Column I			Column II
____	a.	Need for reactor	1. Newspaper
____	b.	No need for reactor	2. AEC
____	c.	Need for atmospheric testing	3. Department of Defense
____	d.	No need for atmospheric testing	4. Department of Agriculture
			5. SANE
			6. Local Power Company
			7. Local Library
			8. International Atomic Energy Agency

Instructional Objectives Hierarchy	Criterion Test Measures
	The learner will then describe, for each potential source, the way he would acquire it from the following selection: interviews, letter writing, news articles, library procedures. He will only be allowed to select one technique for each source, even though many techniques may be used.
4.3 judge the materials for authority, reliability and relevance to the issue under consideration;	The learner will list and apply criteria for judging the reliability, authority, and relevance of the acquired materials to the issues at hand.
4.1.3.1 evaluate the authoritativeness of the sources and/or spokesmen; know that a. it varies with training and experience; b. it varies with personal and institutional goals and interests (i.e., vested interests); c. an authority in one field may not be an authority in another, and that in such cases where an authority is speaking or writing out of his	He will isolate and order, from the following list, those characteristics of authoritative sources: a. Written by well-trained, experienced personnel b. Written by those he feels are truthful, honest, known, political (business, labor, religious, etc.) leaders c. Written by those who stand to gain something by the acceptance or rejection of their position by the public d. Written by the most disinterested e. Written by experts in related fields who are scientists (businessmen, politicians, labor leaders, etc.), but are not, directly, expert in the field f. Written by college professors expert in technical field g. Others to be added

Instructional Objectives Hierarchy	Criterion Test Measures
field, that what he is commenting on must be analyzed closely to determine its accuracy for the subject or the degree of manipulation he intends by posing as an authority;	He will separate the sources into three categories, determined by the degree of authoritativeness. He will isolate and order, from the following list, the criteria for reliability: a. Lacks factual basis but is logical in argument; b. Feels as if it is the correct answer; c. Supports America's position; d. Is technical and factual; e. Is written by a reputable scholar working for the government; f. Is written by expert from power company as an editorial; g. Is written by a technical scholar working for a university; h. Others to be added.
4.1.3.2 evaluates the reliability of the sources and/or spokesmen; know to a. look for adequate detail and specificity; b. identify fallacies and emotionalism; c. look for bias and vested interest; d. distinguish between technical information and popularizations and/or argumentative sources;	He will list the criteria for reliability and will be able to discriminate between the reliable and less reliable authoritative sources listed in Column II for each of the issues in Column I.

Instructional Objectives Hierarchy

4.1.3.3 evaluate the relevancy of the information, sources or spokesmen

- a. determine that the information is really pertinent to the issue, problem or proposal;
- b. avoid making premature or incorrect generalizations;
- c. change set to identify his own biases;

Criterion Test Measures

Column I

- a. Community reactor
- b. Nuclear testing

Column II

1. Local newspaper
2. Scientific American
3. Bulletin of Atomic Scientists
4. Newsletter from those opposing the issue
5. Newsletter from those supporting the issue
6. Others to be added

Given four synopses of articles, with their sources identified, the learner will select those which have the most relevancy, in terms of the given issues, for his decision-making responsibilities. The synopses should be: one on general science, one on the technical aspects of a nuclear reactor, one on the pros and cons of nuclear reactors, and one overtly propagandistic (or any other set of synopses that will allow contrast between those with too little, too much or too biased information).

Nuclear Power Plants

Synopsis 1 - In Life, "Science and Man"

Describes the effect of science on man's life and institutions and makes a few comments on atomic energy and weapons.

Instructional Objectives Hierarchy	Criterion Test Measures
	Synopsis 2 - In *Scientific American*, "Nuclear Power"
	Describes the development of reactors, uses of reactors, safety factors, and development and experiments with breeder reactors.
	Synopsis 3 - In *Saturday Review*, "Do We or Don't We Build Atomic Power Plants"
	Describes the battle over the Bodega Bay power plant site in contrast with the acceptance of the San Owofre site. Gives arguments of both sides.
	Synopsis 4 - *Daily Gazette* (community newspaper), "Let's Keep Our Community Healthy"
	Describes the disadvantages of nuclear power plants, and includes most of the projected dangers of power plants, including (a) they can explode like bombs (b) cause irradiation. Demands that the reactor not be built, since it is too dangerous, and advocates community action to prevent its being built.
	Atomic Bomb Testing
	Synopsis 1 - *Look*, "Atomic Science: New Hope for Man"
	Describes uses of the atom in industry and agriculture. Begins with one paragraph on the bomb.

Instructional Objectives Hierarchy	Criterion Test Measures
	Synopsis 2 - Scientific American, "Half-life and Atmospheric Testing of Nuclear Weapons"
	Describes types and amount of contamination, effects on life, and predicts what would happen if testing started again.
	Synopsis 3 - Bulletin of Atomic Scientists, "The Teller-Pauling Debate"
	Describes the position of two scientists regarding the testing of atomic weapons.
	Synopsis 4 - Reader's Digest, "The Russians Are Testing Again"
	Describes evidence which purports to prove the case, discounts the danger of testing, describes the need for testing, and demands that the government act to save freedom and security.
	Given three general positions regarding the issues, the learner will critique each in light of the evidence gathered thus far to demonstrate that they are (1) incomplete factually, (2) depend too heavily on biased or emotional materials, or (3) ignore evidence for ideological reasons.
	Nuclear Power Plants
	Position 1. "We should not build nuclear power plants. We probably need the new source of power, but they are so dangerous it's not worth the risk."

Position 2. "I don't want to be irradiated. They are proposing to build that plant only a mile from me. See that smoke coming from the oil plant? The smoke from a nuclear plant will bring radioactivity all over this town."

Position 3. "Look, this town needs more power if it is to grow. Just because I work for the power company does not mean I support a nuclear power plant. I live in this community and you who argue that there may be some disadvantages are crazy. There are none at all! So let's build it."

Atmospheric Testing

Position 1. "Atmospheric testing should start again. The air contamination never really hurt anyone, and we could develop a bomb which was 'clean.' A little contamination now may help us protect the country from our enemies in the future."

Position 2. "Atmospheric testing should never be started again. I don't want my baby mutilated. I read that 10,000 people will die as a result of past testing. And now some nuts are asking for it again. How many babies do they want to die this time?"

Position 3. "The communists are plotting against us, they want to take over the world. All this business about babies dying and radioactive contamination is a bunch of lies put out by the Commies to make us grow weak. Don't be afraid. Stand up to them. Let's build bigger and better bombs. Start testing!"

Instructional Objectives Hierarchy	Criterion Test Measures
	Given three choices to make regarding each issue, the learner will first support one, then the others, on both factual and emotional grounds. One of the choices must be his own personal predilection. (This is a role-playing situation in which the learner is challenged to change set.) He is then to critique each choice on the basis of data sufficiency, emotionalism, and premature assumptions. Nuclear Power Plants Choice 1. Build a power plant, since it has no dangers at all and is needed by the country, the AEC and the President have said so, and I believe them. Choice 2. Don't build the power plant, because it may explode or give us all radiation. Choice 3. Build a non-nuclear power plant. That way we know we are safe and will continue to meet our power needs. Atmospheric Testing Choice 1. Start testing again. The enemy has, and the dangers are not real. Choice 2. Don't test again. If we do, the Russians will. The dangers of irradiation are too great. Choice 3. Find some way to test underground. That way we don't have contaminations, and do have testing to protect ourselves.

Instructional Objectives Hierarchy

4.1.4 form tentative conclusions on the basis of the data gathered regarding the issue, problem, or proposal;

4.1.4.1 resist external pressure—political, psychological, propagandistic, etc.,—which may preclude further investigation;

4.1.4.2 realize that limited data may have been collected which may not give a complete picture;

4.1.4.3 realize that all sides of the issue may not have been idenified or explored;

Criterion Test Measures

The learner will evaluate the conclusions of three pseudogroups or individuals in light of authoritativeness, reliability, and relevancy of their arguments regarding the issue, and identify the weakness of each argument on the basis of their: (1) not being able to resist external pressure from authoritative figures (i.e., the President, Congress, the Mayor, etc); (2) not including, ignoring or not knowing relevant data; or (3) not allowing for relevant arguments from the opposition; he will then state his own tentative conclusions regarding the issues.

The conclusions are:

Nuclear Power Plant

Conclusion 1. A nuclear power plant would be a bad thing for our community. I don't know too much about it, but the Mayor and the best newspaper editor in town have come out against it, and that's good enough for me.

Conclusion 2. Building a nuclear power plant is a bad thing. I can remember a few years ago, at Bodega Bay, the government did not care at all where they put the nuclear plant. They wanted to build it over the biggest earthquake fault in North America! If they were that unconcerned with our safety, why should we trust them now?

Instructional Objectives Hierarchy	Criterion Test Measures
	Conclusion 3. I don't want the nuclear plant. I've heard all about it from the Mayor and the Editor. They explode, and that's all I need to know. Why should I go to a community meeting? The only people there are those guys from the power company and the government, and you know what they will tell you! Atmospheric Testing Conclusion 1. The President, my Congressman, and my boss all agree that we must test again. Maybe there is some danger, but I'm sure these leaders would not let us get hurt. We better test again. Conclusion 2. Here are the facts: The Russians are testing; we need bigger and better bombs; we must defend ourselves. It's clear, isn't it, that we must test! Conclusion 3. Don't tell me that! There are no reasons for starting to test. You right-wingers always see Communists under the bed. Look, I don't want to hear your arguments, my mind is made up. No more bomb testing! The learner will then make a preliminary assessment of his own conclusion on the same basis as his critique of the three above conclusions.

	Instructional Objectives Hierarchy	Criterion Test Measures
4.2	evaluate the issue, problem, or proposal on the basis of relevant data, to determine the potential advantages or disadvantages and then formulate a course of action;	Given the following proposal for the solution on the issue for the building of a nuclear reactor power generating plant in his community (See separate sheet for discussion of atomic bomb testing.), the learner will compare the proposed advantages and disadvantages of the proposal in relationship to the empirical needs of the technological innovation; analyze the potential social dislocation which could result from application of the proposal; recognize irrational arguments regarding technological innovation by comparison with the reactions of people to other now-accepted innovations; and, finally, defend his decision to support or reject the proposal on the basis of the facts. Proposal: Since the nation's need for power is increasing at an ever-expanding rate, and since fossil fuels will soon be exhausted, it becomes absolutely necessary to develop nuclear power. The so-called dangers of nuclear power are not true. The benefits to be derived are great. Support your government's and local power company's attempt to modernize your community by organizing a group to fight for the plant.
4.2.1	determine the potential dangers or benefits to life and property	Given the following list of facts regarding the utilization of nuclear reactors for the production of electricity, the learner will (1) separate out the factors that demonstrate the superiority of nuclear power generation over traditional means; (2) separate out the fallacies connected with nuclear power; (3) list the limitations of traditional fuel sources; and finally, (4) identify disadvantages of fossil fuels used to generate electricity, and contrast, for each, how nuclear generation will correct or ameliorate each disadvantage.

Instructional Objectives Hierarchy	Criterion Test Measures
	a. Nuclear production is cheaper. b. Nuclear power more dangerous because of radiation. c. Nuclear plants could explode as a nuclear bomb does. d. Nuclear power production allows significantly less contaminants to escape into the atmosphere, thus reducing smog and other air pollutants. e. Nuclear fuel lasts longer and has a greater potential supply. f. Fossil fuels produce contaminants which cause lung diseases and destroy paint, rubber and other materials. g. Others to be added.
	Fallacies a. Nuclear power plants can explode b. Nuclear plants produce radiation c. Others to be added
	Truth a. Knowledge of physical laws has led to barriers which prevent leakage b. Others to be added

Instructional Objectives Hierarchy — **Criterion Test Measures**

4.2.1.1 categorize the stated dangers of the issue, problem, or proposal and match them against the data collected

Limitation of Fossil Fuels	Correction by Nuclear Power
a. Limited resources	a. Unlimited sources with breeder reactors
b. Great air contamination	b. Little or no contamination
c. Industry tied to available raw materials	c. Industry allowed greater decision making
d. Others to be added	d. Others to be added

4.2.1.2 categorize the stated benefits and match them against the data collected

Given a list of fallacies connected with the use of nuclear power generation, the learner will match the factual replies to those of the fallacies.

Fallacies	Truth
a. Explodes as a bomb does	a. Cannot explode
b. Spreads radiation	b. Cannot by design
c. Others to be added	c. Others to be added

Instructional Objectives Hierarchy	Criterion Test Measures
	Given the list of the purported benefits of a nuclear power generating plant, the learner will identify those that answer the specific social problems listed in a second column. Column I a. Cheaper b. Less contaminants c. Allows greater dispersal d. Longer lasting fuel supply e. Others to be added Column II a. Smog control b. Limited resources c. Urban conglomeration d. Rising costs of traditional fuels e. Others to be added
4.2.2 determine the potential costs —social, economic, political— of the issue, problem or proposal in comparison with current practices, and make decision to act	The learner will state in writing how the wide-scale introduction of nuclear power generation will affect social, political, and economic life in his community, including at least the following points: a. Political effects: Federal and state control of reactor safety will introduce this kind of control into local communities. Decision to build the reactor will oppose federal and local persons and organizations. Safety measures will depend basically on federal and state agencies.

Instructional Objectives Hierarchy	Criterion Test Measures
	b. Economic effects: Power companies will be influenced by federal controls. Prices may go down. Industry will be able to have greater dispersal potential. Less dependency on expensive and limited fossil fuels. c. Social effects: More attractive buildings. Dislocation through condemnation. Greater population dispersal. Less air contamination.
4.2.2.1 compare the relative costs of change with the established pattern or procedure;	The learner shall construct a graph which shows the relationship between fossil fuel supplies and nuclear fuel supplies from 1945 to 1967, and extrapolate to 2000 to draw the necessary conclusion regarding the reserve potential and cost factors: nuclear fuels will be limitless, while the cost of fossil fuels will rise as they become more scarce.
4.2.3 compare the proposal with appropriate historical analogies relative to technological innovations and their impact, as well as present trends in social, political, and economic areas as they are affected by technological change;	The learner will analyze emotional and irrational responses to technological innovations by comparing the introduction of the cotton gin (or other example) with that of nuclear power. Included in the analysis should be an outline of the consequences of the cotton gin on the economic, political, and social life of the ante-bellum periods: production facts, rise of "King Cotton," impact of slavery which was declining, demand for more land which led to a North-capitalist/Southern-agriculturalist competition extending to Congress, pro- and anti-slave struggles, pro- and anti-tariff struggles, and finally the outbreak of the Civil War; similar conflicts between irrational fears regarding nuclear power, the economic and social needs and the potential political changes: including the effect of nuclear power on employment, power production, population dispersal, space demands, foreign policy, and similar matters.

Instructional Objectives Hierarchy	Criterion Test Measures
4.2.3.1 know the comparative statistics between other technological inventions or innovations which are now generally accepted as both necessary and worthwhile (e.g., the automobile), and nuclear science developments;	Given a graph comparing statistical evidence of deaths caused over the last 20 years by automobiles, trains, and airplanes (all acceptable and demanded technological innovations) and by nuclear accidents, the learner will (1) state in writing why the statistical comparison is unfair, (2) identify and compare how governmental controls on safety (from trains, to autos, to airplanes, to nuclear plants) have increased the safety factors in all categories, and (3) draw the conclusion that nuclear power plants under rigid control of state and federal governmental agencies are safe.
4.2.3.2 evaluate the impact of the issue, problem, or proposal on the social aspects of our culture (How will it affect people and institutions?) and the degree to which the change will interface with other elements of the society;	The learner will identify, in writing, how nuclear power production will ameliorate, or not affect, the two following social problems: population explosion and air pollution, including at least the following points: a. Nuclear energy does not need a continuous supply of bulky fossil fuels as a power source. Fossil fuels also need a large amount of air forced through the burning areas to maintain heat; nuclear fuels do not. Thus fossil fuels, through the exhaust system, add unburned (unoxidized) contaminants to the air while nuclear fuels do not. b. Because nuclear power production does not depend on bulky raw materials, but on small amounts of materials, industry and population are relieved from having to consider power and water needs when selecting site locations; they can use other factors (days of sunshine, transportation facilities, etc.).

Instructional Objectives Hierarchy	Criterion Test Measures
4.2.3.3 evaluate the probable effects of the issue, problem, or proposal on the internal political structure of the USA, and on foreign policy;	Given a list of possible changes in the internal political structure which may result from introduction of nuclear power generation, the learner will check those that are least likely to happen. a. Federal control of the power industry b. Greater federal control of the power industry c. More community decision-making regarding power companies' activities d. Greater cooperative action between government and private industry e. Greater government funds for research and development of nucleonics f. Greater federal and state regulations of safety factors
4.3 decide course of action and take appropriate action based upon his investigation and analysis of the issue, problem, or proposal to influence decision-making;	Given the following lists of governmental and private agencies and their appropriate subdivision, the learner will match the issue, problem, or proposal with the 3 agencies most likely to be involved in decision-making by rank (i.e., most important in decision-making first):
4.3.1 identify the principles involved in the decision-making, or having influence on the decision-makers, and their involvement in the decision-making process;	

Issue	Agency
a. Nuclear reactor plant	1. AEC
b. Atomic bomb testing	2. U.S. Congress
c. Atomic bomb treaty	3. President and Cabinet
d. Use of space technology	4. U.S. Senate

Instructional Objectives Hierarchy	Criterion Test Measures	
	Issue	**Agency**
	e. Use of atomic weapons in limited wars	5. Pentagon (Joint Chiefs)
	f. Irradiation of food	6. Food and Drug Administration
	g. Irradiation in industry	7. Local electric company
	h. Occupations in nuclear field	8. University physicists
	i. Underdeveloped world and atomic power	9. Joint Committee on Atomic Energy
	j. Atomic power and foreign policy	10. Dept. of Agriculture
		11. Bureau of Standards
		12. International Atomic Energy Agency
	A. Nuclear Reactor Plant	1. 2. 3.
	B. Atomic bomb testing	1. 2. 3.

Instructional Objectives Hierarchy	Criterion Test Measures
	C. Food and product irradiation 1. 2. 3.
	D. Political and economic power of AEC 1. 2. 3.
	E. Population problem and atomic energy 1. 2. 3.
	Having completed the identification listing, the learner will star that agency, of the three listed for each issue, which has the most vested interest in convincing him of the correctness of the issue.
4.3.1.1 know the specialized governmental and private agencies related to the issue, problem, or proposal and their function;	Define the role of the following governmental and private agencies, and give two examples of the kinds of involvement they would have with the development of nuclear technology including weapon development. a. AEC b. Joint Committee c. Department of Health, Education and Welfare d. Department of Agriculture

Instructional Objectives Hierarchy	Criterion Test Measures
	e. Bureau of Standards f. Power Companies g. American Nuclear Society h. Atomic Industrial Forum i. International Atomic Energy Agency
4.3.1.2 know other agencies or groups interested in the issue, problem, or proposal, or publications which attempt to exert influence on the decision-makers.	Define the role of the following pressure groups, and identify their particular points of view by matching them with those listed. a. SANE b. W.S.P. c. Power companies d. Atomic Industrial Forum e. John Birch Society f. Various Private Organizations composed of retired military men, etc. 1. Opposed to weapons development and use 2. Opposed to nuclear reactors 3. In favor of total use of weaponry 4. In favor of expansion and support of nuclear technology for business reasons, etc.

Instructional Objectives Hierarchy	Criterion Test Measures
4.3.1.3 decide on a course of action by determining the answers to the following questions: a. how serious is the situation (what is the need); b. what alternatives are open; c. which authorities support or oppose the issue, problem, or proposal; d. what position does the evidence support.	The learner will collect and label all positive and negative facts regarding the utilization of nuclear generating plants, and utilize the data gathered to answer the questions below: a. What is the need for the plant? b. What happens if the plant is not built and the old methods are continued? c. Which authorities support or oppose the building of the plant? d. What other facts or factors support or oppose the building of the plant? The learner will then make a written summary of his position which demonstrates (1) disassociation from fallacies, (2) dependency on facts, (3) willingness to withhold judgment, (4) recognition of propagandistic or emotional appeals, and (5) a decision as to his own personal involvement to effect a decision one way or the other.

Instructional Objectives Hierarchy		Criterion Test Measures
4.3.2	determine the method of communication or action that will reach and influence the principals;	Given the following issues, the learner will select the possible courses of action to be taken to influence the decision-making process, and which technique is most appropriate for each issue, by a check. Issue a. Nuclear reactor b. Nuclear weapons c. Test ban treaty d. Introduction of irradiated foods and products Course of Action 1. Organizing the community to support and approve 2. Writing letters 3. Talking directly to officials 4. Picketing 5. More to be added
4.3.2.1	realize that individuals, acting collectively, can affect decisions made by various decision-makers	The learner will match "community action" or "personal action", with the issues listed below in terms of which is more appropriate as a first approach to the problem. a. Using irradiated products b. Atomic weapons testing c. Atomic reactor d. Building of reactor e. Getting radiation treatment f. More to be added

Instructional Objectives Hierarchy	Criterion Test Measures
4.3.2.2 know the possible means of communicating his desires	The learner will arrange in order the techniques of communications in terms of a personal to collective (community, state, national) action validating at least the following: a. join organization supporting or opposing b. picketing Congressmen and other official agencies c. letter writing to officials d. working for candidates e. visiting reactor sites
4.3.2.3 realize that others in his community, state, or nation may also be concerned with the issue, problem, or proposal, and attempt to contact them to gain support for his position through cooperative action;	Identify from a list those organizations made up of private citizens, possibly found in his area, which would be concerned with these issues. a. SANE, PTA, WSP, etc. b. Democratic - Republican parties c. Labor unions d. Power companies e. University academicians f. More to be added

Instructional Objectives Hierarchy	Criterion Test Measures
	After the learner has completed the instructional sequence presented above, he will then be presented an entirely different social issue involving technological innovation (nuclear or non-nuclear). He will be required to follow the same processes he mastered in investigating the issue in the learning design. Criteria for judging learner performance are the same as those identified in the materials above. (In this segment the instructor is given greater options and decision making.)

ATOMIC RESEARCH AND THE PUBLIC WELFARE

Terminal Objective: 4.0 The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose proposed actions or initiate actions himself in regard to the development and/or use of nuclear technology.

Instructional Objectives Hierarchy	Criterion Test Measures
The learner shall:	
4.2 evaluate the issue, problem, or proposal on the basis of relevant data to determine the potential advantages or disadvantages, and then formulate a course of action;	Given the pronouncement by the President that it is necessary for the United States to unilaterally break the atmospheric nuclear test ban treaty to improve its weapons system, the learner will compare the advantages and disadvantages of testing in terms of national defense, foreign policy, and health aspects of atmospheric testing by determining through a study of the relevant data the potential dangers and benefits; potential social, political, and economic costs; and arrive at a decision to support or oppose the government's decision.
4.2.1 determine the potential dangers or benefits to life and property;	The learner will summarize the potential dangers and benefits to life and property (broadly defined to mean national life and property, in this case) of atmospheric bomb testing in a short 2-4 page report which includes at least the following points: Dangers 1. Nuclear weapons are so powerful that in the event of war no victor could emerge; civilization would be destroyed. 2. Spread of nuclear weapons will allow lesser powers to practice nuclear coercion. 3. Nuclear weapons do not deter war, but lead to new forms of war (e.g. limited war, insurrections). 4. Accidental war could come about through escalation. 5. Nuclear weapons tend to maintain attitudes of fear and mistrust of intentions, which would lead to a misinterpretation of acts which, in turn, could lead to nuclear war.

Instructional Objectives Hierarchy

Criterion Test Measures

6. Russians, Chinese, French, and British will begin testing, negating potential advantages and adding greater contamination.
7. Biological damages that will result (details).

Benefits

1. Weapons of such destruction help to deter aggressors from attacking, since they will fear atomic annihilation.
2. Nuclear weapons are needed to balance the greater manpower of our potential enemies.
3. Threat of nuclear war limits potential enemies' freedom of action on a global scale.
4. Maintenance of weapons superiority gives the United States an opportunity for greater freedom of action vis-a-vis potential enemies.
5. Weapons superiority makes it more likely, and believable to potential enemies, that the United States will not only be able to destroy potential enemy weapons, but also to threaten his cities.
6. More testing will lead to clean bombs, more efficient bombs, super bombs, making the country that much safer.
7. Danger of falling behind Russia and China is too great a chance to take.

Instructional Objectives Hierarchy	Criterion Test Measures
	From the following list of arguments relative to nuclear bomb testing, the learner will: (A) Separate those in favor of testing from those which oppose; and then, (B) From within both, separate the apparently emotional arguments from those which are apparently factual, and list them. 1. Weapons so destructive no hope for victory. 2. Nuclear weapons deter enemies. 3. Nuclear weapons do not deter war but lead to new forms of war. 4. Maintenance of weapons superiority allows the United States more strategic freedom of action. 5. Babies will be born deformed from irradiation. 6. Nuclear weapons are needed to maintain superiority over manpower potential of enemies. 7. New arms race will start. 8. Accidental nuclear war could result from escalation. 9. Nuclear weapons will contaminate the air, but danger of attack makes risks worth it. The learner will match the pro and con arguments for weapons testing to determine areas of agreement and conflict. He will then match the areas of disagreement with testimony presented below, to identy possible solutions to the disagreements from a radiation biologist; members of Joint Chiefs; Soviet Embassy; statistical summary of contamination from previous testing by two politically oriented physicists; and one nonpolitical nuclear physicist.

Instructional Objectives Hierarchy

Criterion Test Measures

Testimony 1: Biological Effects

Any radiation exposure is potentially harmful to animals and plants. Radiation can cause cancer, mutation, and a host of other effects resulting in destruction of life. The testing of nuclear weapons adds radiation substances to air, soil, plants, water and animals, which can be passed on to humans. The longevity of these radioactive substances ranges from a few hours after the explosion to 100 years after the explosion. Thus, biologically, the effects of testing are not only dramatic but long-lasting.

Testimony 2: Military Needs

It is quite clear that the major reason for the reluctance of the USSR to get involved in military conflict with the USA has been the USA's ability to completely destroy the Russians. Militarily, we need to continue to develop weapons of superiority vis-a-vis the Russians. The only way to maintain the superiority we now have, however, is to see what actually happens to our bombs and objects below the bomb. We can only find this out by atmospheric testing.

Testimony 3: Reaction of Potential Enemies

The Honorable Ambassador from the United States: It has come to our attention that the present Government of the United States intends to break the treaty regarding atmospheric testing of nuclear devices. We wish to inform your Government that in this situation, we also will begin to test to defend our socialist fatherland and protect our fraternal nations. We cannot allow capitalistic emperialism to destroy socialism!

In addition, your decision to test will cause the destruction or mutilation of millions of innocent people of Africa and Asia as well as Europe and North and South America. Consider that in your final decision.

Testimony 4: Statistics Regarding Half-Lives of Major Contaminants Resulting from Atom Bomb Explosions

Strontium - 90	25 years
Ruthenium - 103	39.8 days
Rhodium - 106	30 seconds
Iodine - 131	8 days
Barium - 140	12.8 days
Cerium - 144	590 days
Praseodymium - 144	17 minutes

Testimony 5:

Pro-Testing. As a scientiest who once lived under a totalitarian regime, I know the evils of such systems. We cannot allow that to happen in America. My former homeland is now controlled by Communists. Of course, I will admit that there is some danger in testing, but it is a necessary risk—freedom is much more important.

Anti-Testing. As a scientist concerned with the biological aspects of testing, I cannot support testing. I have facts which show how many mutations, deaths, etc. will occur from the previous testing periods. I have been to the Soviet Union, and have seen what they have accomplished for themselves. They don't want war, and they have told me that over and over. Of course, I will admit that they might be really dangerous to our freedom, but I don't think they want war. Thus, we must not test in order to protect our citizens and other people from the horrors of irradiation.

Testimony 6: Non-political Physicist

The fission or fusion explosion creates particles which have half-lives of various lengths. These particles combine with skin, plants, soil, and so forth, and retain their potential for irradiating other things when brought into contact with them. Strontium 90, for example, which has a half-life of 25 years, is very similar to calcium which is needed for bone development in humans. It has been found that when Strontium 90 is created by an atmospheric test in Nevada, the winds blow the Strontium 90 across the U.S.A. It finally settles to the ground, where it contaminates the grass eaten by cows, is converted to milk, and is finally drunk by children. The Strontium 90 continues to be potent enough to cause bone cancer in children. Other particles produced by atmospheric testing have, in varying degrees and time limits, a similar effect on plants and animals.

After reading the testimonials, the learner should identify those which contain biases and/or vested interests in the position they maintain, emotional or other irrational argument, oversimplifications and flaws in fact, and select the three sources which seem to offer the best data source which are (1) statistical summary, (2) non-political physicist, (3) radiation biologist.

Instructional Objectives Hierarchy	Criterion Test Measures
	The learner will construct a graph from given statistics regarding the arms race of World Wars I and II, and the current arms race with the Soviet Union, and derive a tentative hypothesis regarding the effectiveness of arms as a deterent to war.
4.2.2 determine the potential costs—social, economic, political—of the issue, problem, or proposal in comparison with current practices and make a decision to act;	Given a series of potential outcomes regarding the social, economic, and political costs, (based on expert testimony from both sides) if nuclear testing is or is not reintroduced, the learner will write his position statement by countering each argument opposed to his position in each of these areas. The learner will check each of the following items in the social, economic, and political areas which may result if atmospheric testing is reintroduced. Social _____ 1. Radioactive contamination of soil, food, humans _____ 2. Potential increase in mutations _____ 3. Increased irrationalism regarding use of nuclear energy _____ 4. Fatalism regarding war _____ 5. More to be added

Instructional Objectives Hierarchy

Criterion Test Measures

Economic

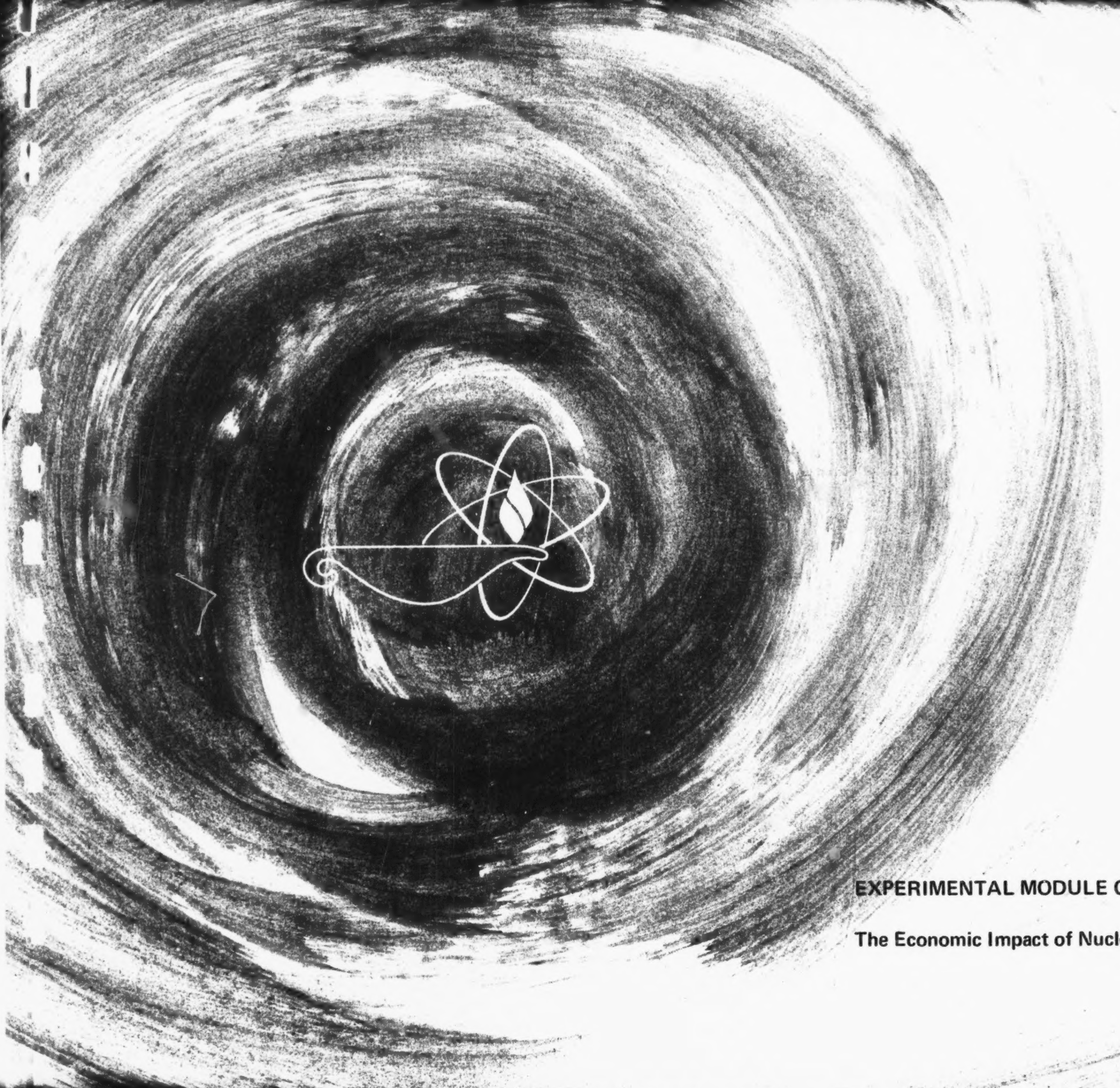
____ 1. Increased defense spending
____ 2. Increased dependence on military spending for economic stability
____ 3. Decrease in GNP
____ 4. Decrease in jobs
____ 5. Increase in government-business competition
____ 6. Decrease in private sector
____ 7. More to be added

Political

____ 1. Soviets respond in kind
____ 2. World tensions rise
____ 3. Decrease in influence of the military on political decision-making
____ 4. More to be added

He will then compare, in a one-page statement, the social, economic, and political changes with the potential of not changing as announced by the President, and conclude whether or not he thinks the change is worth it.

Instructional Objectives Hierarchy	Criterion Test Measures
	The learner will summarize the pro and con data, and then decide a course of action by answering the following questions: 1. What is the need for resuming testing as stated by the decision-maker? 2. What alternatives are open to answer the need if testing is not started again? Are they as satisfactory as testing? 3. Which objective authorities support or oppose the position; which non-objective authorities do? 4. What position does the evidence suggest as the best possible solution?
4.2.3 compare the proposal with appropriate historical analogies relative to technological innovation and their impact, as well as present trends in social, political, economic areas as they are affected by technological change.	The learner will report on the decision to use or not use gas in World War I, and the consequences of the use, including facts about: The race to produce gas, the race to produce counter-measures, the use and effectiveness of gas war (in World War I); the growth of value questions regarding "humane" and "inhumane" weapons of war, conventions regarding weapons use. The learner will also report on the role of military expediency in the development of nuclear engineering science, and its impact on peaceful nuclear applications after World War II. After the learner has completed the instructional sequence above, he will then be presented an entirely different social issue involving technological innovation (nuclear or non-nuclear). He will be required to follow the same processes he mastered in investigating the issue in the learning design. Criterial for judging learner performance are the same as those identified in the material above. (In this segment the instructor is given greater options and decision making.)



EXPERIMENTAL MODULE OF INSTRUCTION

The Economic Impact of Nuclear Power Reactors

SOCIETAL CONCEPT CURRICULUM MODULE OF INSTRUCTION

UNIT: The Economic Impact of Nuclear Power Reactors

COURSE INDEX: United States History, Secondary Level
Underdeveloped Area Studies, Secondary

THRESHOLD KNOWLEDGE: This unit assumes that the learner has been exposed to:

- a. Basic nuclear science concepts;
- b. Substantive knowledge of the operation of nuclear reactors.

UNIT OBJECTIVES: The learner will be able to:

- a. Identify, compare, and evaluate traditional and nuclear power production;
- b. State the needs and advantages of nuclear power over traditional methods by relating these to typical problem situations;
- c. Master the techniques of rational inquiry.

RATIONALE FOR MODULE: This unit introduces two factors to the learner, both of which are essential elements of the curriculum design:

- a. The decision making processes;
- b. Relevant data regarding the impact of technology on economic institutions and practices using nuclear technology as a vehicle.

PROFICIENCY TEST FOR SOCIAL SCIENCE MODULE

The learner will select from the choices offered those items which indicate:

a. A capacity to identify factual evidence regarding nuclear power production;
b. An understanding of the socio-economic implications of nuclear power;
c. An awareness of the processes of rational inquiry.

THIS IS BOTH A PRE AND POST TEST

1. Indicate by placing a check before the item the common fallacies regarding nuclear power generation.

_____a. Nuclear reactors may explode such as atomic bombs do.
_____b. Working in a nuclear plant is dangerous because of radiation coming from the reactor.
_____c. Nuclear power production has a fuel base which guarantees unlimited power for the future.
_____d. Nuclear reactors emit deadly radiations through their exhaust systems which could contaminate a community.
_____e. Nuclear power generation makes it possible to provide less expensive power to the consumer.

2. Indicate the present or potential socio-economic implications of nuclear power generation by placing a check before the statements which are true regarding the use of nuclear power.

_____a. Air contamination will lessen.
_____b. Fossil fuel prices will decrease.
_____c. Population and industry will be able to disperse into presently unused lands due to nuclear power's capability in terms of site location and the production of fresh water.
_____d. Underdeveloped nations without ready supplies of traditional fuel sources will be able to build a power based upon nuclear resources.
_____e. Fresh water supplies will increase and desert areas can be irrigated with water supplied through nuclear desalinization.
_____f. Big government will take control of power production to ensure safety and reasonable development of nuclear power.

3. Label the following statements (A) for authoritative, (B) for biases or containing vested interest, and (NF) for nonfactual or fallacious. The statements are concerning the need and dangers of having a community nuclear power plant built.

_____a. "Tampering with the atom is the work of the devil," said the clergyman, "and if we allow this further tampering by building a nuclear power plant, we will surely be destroyed."
_____b. "Modern nuclear power plants are constructed in a much different way than is an atomic bomb," said a representative for the Atomic Energy Commission, "thus, they cannot possibly explode like one."
_____c. "As city planner for this community, I can say that if we are going to provide for the present and future needs of our population and industry, we must build a nuclear power generator."
_____d. "I say that to build a nuclear power plant is bad," said the owner of the local coal company, "since they are dangerous. The old way is best."

4. Identify the agencies which will have information regarding the building of a nuclear power plant by checking them in the following list. Then label each in the following manner to show which method of contacting them and acquiring information from them (one label per identified item): (L) for Letter, (I) for Interview.

_____a. Atomic Energy Commission
_____b. Joint Committee on Atomic Energy
_____c. Local Power Company
_____d. Department of Defense
_____e. Department of Agriculture
_____f. Local University Physicist

5. Assuming that your congressman refuses to hold a hearing regarding the siting of a proposed nuclear power plant and you and others in your community oppose the site selected, number the following courses of action from 1 to 4 in terms of the sequence of rational procedures to influence the congressman's point of view.

_____a. Picketing
_____b. Letter writing campaign
_____c. Committee formed to contact representative face to face
_____d. Newspaper ads and meetings

SEQUENTIAL HIERARCHIAL LEARNING PATH

Content and Processes Involved in the Investigation of the Implication of Nuclear Power Generation

A. Need for Nuclear Power:
   1. A high standard of living depends upon the power that is available to a country. Little power usually means an underdeveloped economic system and a low standard of living. Exploitation of all sources of power, then, becomes necessary if the United States is to maintain its standard of living.
   2. Current reserves of fossil fuels will be exhausted in 200 years with those most easily mined gone in 100 years.
   3. Energy consumption in the United States doubles every ten years.
   4. America's need for power has been growing at an average rate of four percent over the last decade and with our population growth and continued industrial expansion, this power needs growth will continue at a faster rate.
   5. United States population is growing at a constant rate of 1.7% per year from 1900-1967 and while some leveling off is to be expected, it is also expected that the United States will have a population of over 320,000,000 by the year 2000.

Objectives to Be Obtained

1. State the socio-economic needs for nuclear power production.

Content and Processes Involved in the Investigation of the Implication of Nuclear Power Generation	Objectives to Be Obtained
B. Advantages of nuclear power generation in comparison with fossil fuels: 1. Overall costs of generation of electricity are equal to and potentially cheaper than electricity generated by fossil fuels. 2. Raw materials for nuclear fuel will last at least 1700 years and will be limitless when breeder reactors have been perfected. 3. Use of nuclear power as an energy source in industrial areas will help lessen air pollution since pollutants from reactors are insignificant. 4. Utilization of nuclear power will allow for industrial and population dispersal since new areas can be opened and/or industry will no longer be constrained by power needs. 5. Fossil fuel prices will go down as nuclear power gains wider usage.	2. Identify and compare the advantages and disadvantages of nuclear power with the disadvantages of traditional techniques.
C. Socio-economic implication of nuclear power production: 1. Increased involvement of the government in economic decision making; 2. Less cost for power and fossil fuels which will be used for other purposes; 3. Greater economic regional planning to make the system more rational; 4. Greater dispersal of population and industry;	3. Identify the relationship between socio-economic problems and the use of nuclear power.

Content and Processes Involved in the Investigation of the Implication of Nuclear Power Generation	Objectives to Be Obtained
5. Amelioration of such social problems as air pollution, water supplies, urban congestion; 6. Introduction of new occupational fields; 7. More sophistication in the use of computers and other automatic processes.	
D. Processes of Rational Inquiry to Be Introduced: 1. Identify sources of information relative to the selected issue; 2. Analyze the authoritativeness, reliability, and relevance of the sources; 3. Analyze the cost/benefit factors necessary for a rational decision. 4. Analyze and determine individual courses of action.	4. Utilize established criteria for rational decision making to arrive at a decision regarding the given social issue involving nuclear power.

CRITERION TEST MEASURE
FOR INSTRUCTIONAL OBJECTIVES

Instructional Objectives	Learning Steps/Activities
4.0 The learner shall, when faced with the necessity to make decisions regarding his community's, state's, and nation's needs, be able to knowledgeably support or oppose actions or initiate actions himself in regard to the development and/or use of nuclear technology;	Introducing the Unit: The teacher presents the problem which has arisen from the suggestion that a nuclear power plant be built in a community (see presentation of issue in Social Issue 1). Dialogue with the learners to gain their initial impression regarding the issue which leads to the listing of a number of procedural questions: (1) Are the statements made, accurate? (2) How do we determine their accuracy? (3) Where do we get information? (4) How do we judge the accuracy of the information? and (5) What actions would we take if we had to decide?
4.1 seek and evaluate materials pertinent to the particular issue, problem or proposal;	Gaining Information: The students are directed to identify the key words in the statement (nuclear power, atomic bomb, etc.) and are asked to list the possible sources for finding further information based on the key words (card catalog, Reader's Guide, encyclopedias, etc.).
4.1.1 locate sources of information from both producers and distributors of information;	The teacher then suggests that there may be other more specialized sources of information that may be identified by a preliminary scanning of the preliminary sources. The teacher directs the learners to list all the agencies and other potential sources of information mentioned in the library sources (AEC, Joint Committee, international agencies, and others can be found). The class makes a preliminary check of the relevancy of the information so gathered by comparing the information with the key words previously identified.

Instructional Objectives	Learning Steps/Activities
	The teacher then directs the class to compare the technical information found in the encyclopedia with those of selected magazine articles (technical and nontechnical) and asks the learners to categorize the sources into technical and nontechnical groupings. From this activity a set of criteria for technical/nontechnical information should be developed for future use including at least the following points: objective, scientifically accurate, non-argumentative, lacking vested interest (define).
4.1.2 acquire the materials from a variety of sources;	The learners devise a system for acquiring materials from a variety of sources by analyzing how much time and distance is involved. The learners break down the categories into three parts: library research, letters of request, and interviews. The materials and information are then acquired by the most efficacious means.
4.1.3 judge the materials for authority, reliability and relevance to the issue under consideration;	The teacher presents to the learners three very obvious articles written from the standpoint of technical information, emotional views, and vested interests written by authorities and nonauthorities. The learners are directed to categorize as best they can the articles in terms of which one appears to be most authoritative (define), which appears to be objective data and which appears to be argumentative, persuasive, or emotional, and which appears to contain vested interest (define). From this activity the learners are directed to develop a set of criteria for judging authoritativeness and reliability including at least the following: (See set of criteria in point 4.1.3.) The sets of criteria are then applied to the acquired materials and from this screening the learners are asked to isolate the factual evidence regarding nuclear power generation from the unfactual or irrational.

Instructional Objectives	Learning Steps/Activities
4.1.4 form tentative conclusions on the basis of the data gathered regarding the issue, problem or proposal;	The teacher directs the learners to compare the factual, authoritative information with the opinion stated in the case study presented at the beginning of the unit and form a tentative conclusion regarding its intent and accuracy. The learner is then given a set of three conclusions which point out (1) a conclusion based on the effect of external pressure, (2) one based on limited data; and, (3) one based on information representing only one side of the issue. All conclusions should come from apparently authoritative sources which are identified in an appendix to each conclusion. The class is then directed to match known information to each conclusion to gauge the reasons for the inadequacies of each conclusion including at least the following. (See points made under 4.1.4.) The teacher then has the learners apply the criteria to their own conclusions and make any modifications that become apparent.

Instructional Objectives	Learning Steps/Activities
4.2 evaluate the issue, problem or proposal on the basis of relevant data to determine the potential advantages or disadvantages and then formulate a course of action;	Analyzing the Issue: At some point during the investigation of the issue, when enough is known about the proponents and opponents of the nuclear power plant, the teacher should develop a role playing situation with learners involved in opposing groups, with the elements of bias, vested interest, disinterest, and so forth, built into the role playing situation. Most likely a mock community could be established with each viewpoint or pressure group identified.
4.2.1 determine the potential dangers or benefits to life and property;	The learner is directed to analyze the proposal for the solution of the issue posed by the unfactual case presented by the opposition group by matching the factual evidence against the fallacious charges made by the opposition on the basis of the needs of society for nuclear power. The teacher asks: "Are there dangers involved in the development of a nuclear power plant?" He then challenges each response with whatever arguments are necessary to motivate the learner to a stronger defense of his position, e.g.: Learner: No dangers involved. Teacher: Atomic bombs explode as a chain reaction and power reactors also utilize this physical fact. Thus they could explode too. When the learners have been given these challenges, the teacher directs them to isolate each fact and fallacy and to also identify the needs for technological innovation from the information already acquired or from further research. The learner is directed to gather statistical data concerning: power needs and population/industrial growth; risks/benefits factor in auto, train, airplane, and nuclear use; government control factors regarding the four areas above. From this evidence the learner should derive a conclusion regarding the relationship between government control and safety and regarding the relative safety of nuclear power generation with the other three.

Instructional Objectives	Learning Steps/Activities
4.2.2 determine the potential costs—social, economic, political—of the issue, problem or proposal in comparison with current practices and make decision to act;	The teacher will direct the class to report on the relationship of social and economic problems and how these might be ameliorated through the use of nuclear power generation. Included should be the following points: (See points made under Criterion Test Measure column, point 4.2.2.) The learner is then directed to summarize all known factors including: (1) technical information regarding nuclear reactors and power generation, (2) social and economic problems or issues or dislocations, (3) analysis of unfactual, emotional, biased appeals and the potential dislocation which could result from them. From this summary the learner is asked to answer the following questions (these questions involve value judgments and therefore are open to class discussion). The teacher and learners evaluate each judgment on the basis of previously derived criteria and information (i.e., the degree of authoritative support, technicality, lack of emotional bias, vested interest, etc.): (See questions listed under point three in the "Instructional Objectives" column.)

Instructional Objectives	Learning Steps/Activities
4.2.3 compare the proposal with appropriate historical analogies relative to technological innovation and their impact as well as present trends in social, political and economic areas as they are affected by technological change;	The teacher poses the question of why people develop irrational attitudes toward technological innovations. Through dialog, the learners should suggest that irrationalisms develop from nondependence on technical information, objective information; or is affected by vested interest, bias, and fear of change. To test these generalizations, the teacher directs the learners to investigate and report on the following historical studies: (1) the invention of the cotton gin in terms of its impact on society and as an example of unconscious innovation in society and its consequences; and (2) the development of the mechanized textile industry where the Luddite reaction occurred as an example of a conscious awareness of the innovation. From this contrast of the unconscious and conscious factors of change, the learner should be asked to form a hypothesis regarding technological innovation which could be used in today's situation as well as historical instances (and which will be tested in later units). Essentially, the hypothesis should contain elements which suggest: (1) consciousness of technological innovation helps one to be prepared; (2) unconsciousness of change leaves one with a feeling of helplessness (anomie, alienation, etc.); and (3) consciousness of change helps one to become a better decision maker in a democratic society by allowing the decisions to be made more rationally. From the historical analysis and comparison, the teacher directs the learners to list potential sources of irrationalisms in the arguments of those opposed to the building of the nuclear power plant.

Instructional Objectives	Learning Steps/Activities
	During the course of the historical investigation of the Luddite reaction, the teacher develops a role playing situation for the learner to have him first take the role of an employer and then of the unemployed handicraft worker.
4.3 decide a course of action and take appropriate action based upon his investigation and analysis of the issue, problem or proposal to influence decision making;	By this point in the unit a consensus should have been formed regarding the proposal and the issue: those opposing the nuclear power plant are wrong factually and are using arguments based upon irrational feelings or vested interest. The learners are asked to identify what can be done to prevent the opposition from succeeding in its goal. From this discussion the learners should isolate a number of potential courses of action.
4.3.1 identify the principals involved in decision making or having influence on the decision makers and their involvement in the decision making process;	The teacher asks the learners: In this case (i.e., the issue at hand), which agencies previously identified are most susceptable to influence? (AEC, Congress, power companies, etc.) Why? The class is led to discriminate between those in favor of the project on the bases of (1) their own vested interest in seeing it completed, (2) their obligations to other agencies or directives, and (3) their responsibility to the community and nation in terms of the long-range needs. The class then analyzes each of the agencies identified to discover their motivation for supporting the power plant construction to identify further the type of influence it might respond to.

Instructional Objectives	Learning Steps/Activities
4.3.2 determine the method of communication or action that will reach and influence the principals.	The teacher devises a number of role playing situations which will involve the learners in attempts to influence decision making in the face of indifference, opposition and other constraints. The roles should also involve the learner becoming aware that in some situations individual actions are enough, while in others collective action is needed.

References and Resources

(Resources followed by an asterisk will have to be prepared by the teacher.)

United States Atomic Energy Commission Publications

1. "Atomic Energy in Use"
2. "Atomic Power Safety"
3. "Atoms in Agriculture"
4. "Careers in Atomic Energy"
5. "Civilian Nuclear Power," A Report to the President, 1962
6. "Food Preservation by Irradiation"
7. "Our Atomic World"
8. "Radioisotopes in Industry"
9. "Research Reactors"

Other Useful Publications

1. Edison Electric Institute, Atomic Power Progress
2. Esso Research and Engineering Company, 101 Atomic Terms and What They Mean
3. Department of Health, Education and Welfare, Nuclear Science Teaching Aids and Activities
4. Smith, C. B., Nuclear Energy Laboratory, UCLA, Nuclear Power
5. American Nuclear Society, Nuclear Power Reactor Siting
6. U. S. Federal Power Commission, World Power Data

Motion Pictures

1. Atomics International, Atomic Furnaces
2. AEC, Atomic Power and the United States
3. AEC, Harvest of An Atomic Age
4. AEC, The Atom Comes to Town
5. Handel Films, The Magic of the Atom, (series on applications of the atom)

References and Resources

Transparencies*

1. Statistical Comparison of Atomic and Fossil Fuel Potential
2. Statistical Comparison of Safety in Nuclear, Auto, Airplane and Train Fields
3. Decision-Making Model in a Democracy

Professional Aids

1. Fenton, Edwin, The New Social Studies, Holt, Rinehart and Winston
2. Schmuck, Chesler and Lippitt, Problem Solving to Improve Classroom Learning, SRA
3. Chesler and Fox, Role Playing Methods in the Classroom, SRA
4. Oliver and Shaver, Teaching Public Issues in the High School, Houghton Mifflin

EXPERIMENTAL MODULE OF INSTRUCTION
BASIC ATOMIC STRUCTURE

NUCLEAR SCIENCE CURRICULUM MODULE OF INSTRUCTION

UNIT:	Basic Atomic Structure
COURSE INDEX:	This unit should be taught in an eighth grade general science course of study.
THRESHOLD KNOWLEDGE:	There is no prerequisite for this unit. It is the first of the series and provides the foundation knowledge for succeeding units.
TERMINAL PERFORMANCE OBJECTIVE:	Using a periodic table, the learner will be able to identify and state the atomic number of a given element; the number of protons in the nucleus of a given element; an estimate of the number of neutrons in a given element; and the number of orbital electrons in a given element. The units provide the technical knowledge required to understand the effects of radiation on matter and thus the ramifications of these effects for the use of irradiated products, using radiation methods for medical diagnosis and treatment, and working with radioactive materials.

SEQUENCED LEARNING PATH

Present Concepts of Atomic Structure

a. Nucleus composed of:

	Symbol	Charge
neutrons	n	0
protons	p	+

b. Orbital electrons

Energy levels, binding energy, ionization potential

c. Terms and symbols

	Symbol
1. Mass number	A (superscript)
2. Atomic number	Z (subscript)
3. Definitions of nucleon, nuclide, isotope, ion, ionization	

d. Periodicity of the elements

Instructional Objectives

TERMINAL OBJECTIVE. Shown a Periodic Table, state: the atomic number of a given element; the atomic weight of a given element; the number of protons in the nucleus of a given element; and the number of orbital electrons in a given element.

1. State the symbol and charge for neutron, electron, proton.
2. State mass relationships between neutrons, protons and electrons.
3. Identify the definition of a nucleon.
4. Identify the definition of a nuclide.
5. Identify the definition of atomic weight.
6. Distinguish between atomic weight and atomic mass.
7. Given an element with its mass number as a superscript and its atomic number as a subscript, distinguish one from the other.
8. Given the components of a carbon atom, construct a diagram according to Bohr's postulate of an atom.

PROFICIENCY TEST FOR MODULE

Stimulus	Response
The Periodic Table of Elements from the Periodic Table	
1. The atomic number of tin is_____.	1. (50)
2. The atomic weight of oxygen is_____.	2. (16)
3. How many protons are in the nucleus of carbon?	3. (6)
4. How many neutrons would you estimate to be in the nucleus of carbon?	4. (6)
5. How many electrons would you estimate aluminum contains?	5. (13)

This test may be used as a pre-test and a post-test to measure learner performance. Any one of the elements on the Periodic Table may be substituted in the above test to eliminate pre-post test carry-over.

Learning Steps/Activities	Instructional Objectives
1. State the symbol and charge for neutron, electron and proton. Develop the basic vocabulary and concepts of atomic structure through an historical approach. Definition of an atom Size concepts of an atom (Use comparisons with familiar objects and numbers)	Given the terms neutron, electron and proton, the learner will be able to prepare a chart indicating the symbol and electrical charge for each particle.
2. State mass relationships between neutrons, protons and electrons. The discovery of the atomic nucleus The discovery of the electron Space concepts in an atom (Make a comparison with the macroscopic world)	Given a list of atomic particles the learner can prepare a list identifying mass relationships between neutrons, protons and electrons.

Criterion Test Measures

STIMULUS

Complete the following chart by indicating the symbol and electrical charge for each of the particles:

Particle	Symbol	Charge	RESPONSE	
Neutron			(n)	(o)
Electron			(e)	(-)
Proton			(p)	(+)

STIMULUS

Atomic Particle	Relative Mass	RESPONSE
Neutron	________	Approximately same mass as proton
Proton	________	Approximately 2000 times an electron
Electron	________	Approximately 1/2000 of a proton

References and Resources

* 8th Grade Text
The Atom and the Earth
Chap. 4, Sec. II B

Transp. - Relative size of Atom to learner's environment

Film - How Big is an Atom?

Single Concept 8 mm loops
1 (Size Relationships of Atoms)
2 (Space Relationships within an Atom)

Selected Readings of the contribution of specific scientists to our knowledge of atomic structure and their experimental approach.

Rutherford
Planck
Bohr
Dalton
Thomson

Learning Steps/Activities	Instructional Objectives
3. Identify the definition of a nucleon. How electrons are attracted and "held" by the nucleus The discovery of protons and the relative mass and charge of protons and neutrons The necessity of neutrons to account for the mass of the atom (No charge; mass = proton) Discuss and define a nucleon	Given a definition of a nucleon, the learner will be able to identify that protons and neutrons are referred to as particles and nucleons.

Criterion Test Measures

References and Resources

Protons and neutrons are both called

____ A. Particles
____ B. Nucleons
(X) Both
____ Neither

Learning Steps/Activities	Instructional Objectives
4. Identify the definition of a nuclide. Explain to the learners that the difference between atoms of different elements is in the number of the particles of which they are composed. Specifically, the atoms of each element have different numbers of protons and, therefore, also electrons. Show some models of simple atom structure and have the learners diagram these models on the board, identifying the structural parts of hydrogen and helium. Discuss the value of a 3-dimensional model as opposed to a drawing. When the learner is doing helium, show how the number of neutrons can vary within the atoms of a given element. Then define isotope and nuclide.	Given a description of the term "nuclide", the learner will be able to determine it as an atomic species characterized by the number of protons and neutrons it contains.

Criterion Test Measures

The term "Nuclide" is used to describe

____ A. both protons and neutrons

(X) B. an atomic species characterized by the number of protons and neutrons it contains

____ Both

____ Neither

References and Resources

8th Grade Test
The Molecule and the Biosphere
Chap. 10, Sec. III A

Transp. Atomic Structure
(Series of overlays)

Film - A is for Atom
(5.4.4)

Film Strip - Exploring the Atom

Models - Models of simple atoms that can be taken apart.

Learning Steps/Activities	Instructional Objectives
5. Identify the definition of atomic weight. In a discussion define atomic number and atomic weight. Using the Periodic Table, show how to distinguish one from the other.	Given a series of statements relative to atomic weight and atomic mass, the learner can identify the characteristics of each.
6. Distinguish between atomic weight and atomic mass. Account for the fact that individual isotopes of an element have an atomic mass that is a whole number, while the atomic weight of an element is usually shown as a decimal.	

Criterion Test Measures

The atomic weight of an element

____ A. is the weighted mean of the masses of the neutral atoms of the isotopes that constitute the element

____ B. can differ slightly from the atomic mass number because of the presence of isotopes

(X) Both

____ Neither

References and Resources

8th Grade Text
The Atom and the Earth
Chap. 4, Sec. IV

Table:	Periodic Table
Transparency: (2.1.16)	Periodic Table of Elements
Film Strip: (3.3.3.3)	Atomic and Molecular Weights

Learning Steps/Activities	Instructional Objectives
7. Given an element with its mass number as a superscript and its atomic number as a subscript, distinguish one from the other. Demonstrate on the board how a specific nuclide is designated with the atomic mass number as a superscript and the atomic number as a subscript. Explain how to determine the number of neutrons in a nuclide by subtracting the atomic number from the atomic mass. Continue with the diagrams of successively heavier elements by indicating a specific isotope of the element and eliciting from the class the number and location of particles composing each. Concept of energy levels could be introduced here as background for other, later objectives, e.g., ionization and chemical bonding. Should expect learners to be able to diagram electron configuration for elements 1-20.	Given the designation of a specific isotope of an element including the mass number and atomic number as sub and superscript, the learner will be able to identify the proper script which designates the atomic number and mass.

Criterion Test Measures

In the expression $^{235}_{92}U$

____ A. the superscript (235) is the atomic number

____ B. the subscript (92) is the atomic mass

____ Both

(X) Neither

References and Resources

8th Grade Text
The Atom and The Earth
Chap. 4, Sec. IV, A, 2

Transparencies of atomic structure previously used.

Model of atoms used prior activity

8th Grade Text
The Molecule and the Biosphere
Chap. 10, Sec. III A.

Learning Steps/Activities	Instructional Objectives
8. Given the components of a carbon atom, construct a diagram according to Bohr's postulate of an atom. Select specific nucleons from elements 1-20 and ask learners to draw diagrams, showing number of protons and neutrons in the nucleus and the number of electrons in the various energy levels. Terminal Performance Objective Shown a Periodic Table, state: the atomic number of a given element; the atomic weight of a given element; the number of protons in the nucleus of a given element; an estimate of the number of neutrons in a given element; and the number of orbital electrons in a given element.	Given the components of a carbon atom the learner can construct a diagram according to Bohr's postulate of an atom.

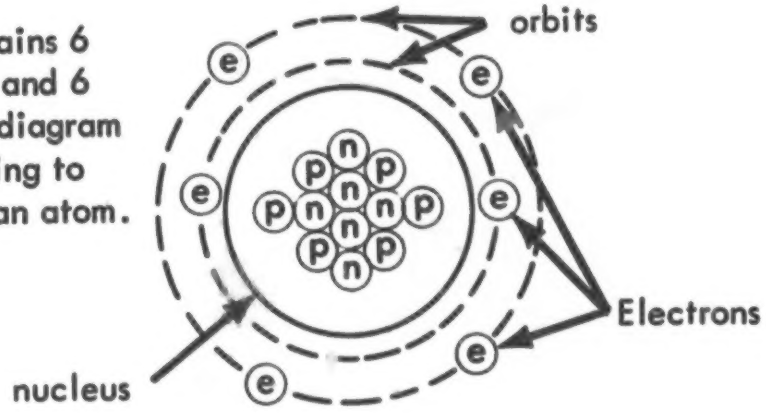
Criterion Test Measures

References and Resources

STIMULUS

A carbon atom contains 6 protons, 6 neutrons and 6 electrons. Draw a diagram of this atom according to Bohr's postulate of an atom.

RESPONSE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Electrons
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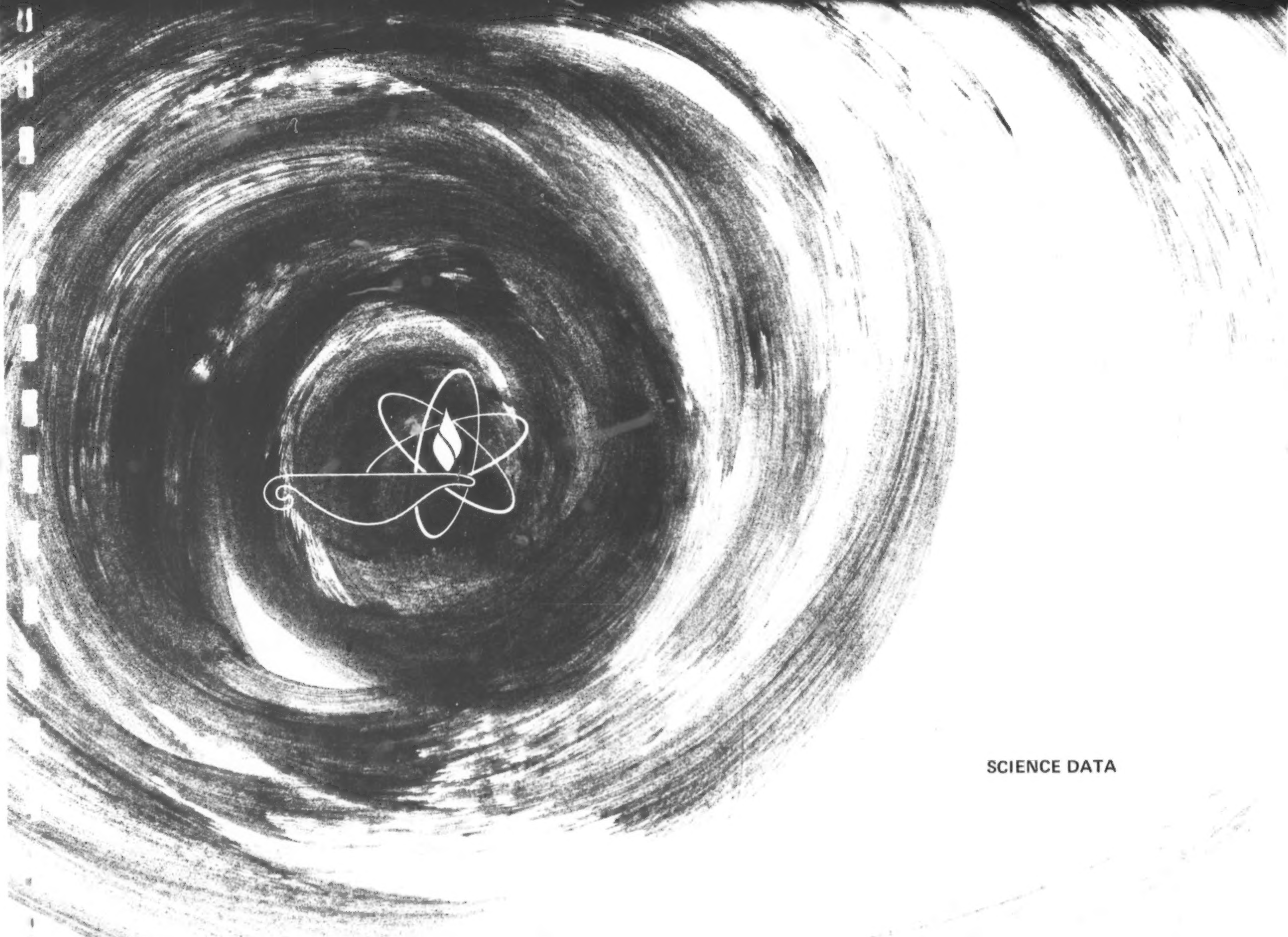
8th Grade Text
The Atom and The Earth
Chap. 5, Sec. II



SCIENCE DATA

TURN PAGE

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
I.A.1 Background Concepts of Nuclear Energy		
1. Given a brief description of the Rutherford experiment in 1911 involving the scattering of alpha particles, the learner will be able to state (1) the essential elements in the experiment and (2) the significant conclusion postulated by Rutherford.	In 1911, after a series of experiments in which he studied the scattering of __________ by thin sheets of metal, __________ postulated that the __________ contains a central charge distributed over a small volume. Later (1912) he called this region the __________.	 (Alpha particles) (Rutherford) (atom) (nucleus)
2. Given a series of statements about the release of electromagnetic energy from the orbital electrons of an atom, the learner will identify that the energy is released in discrete packets or quanta.	When waves of electromagnetic energy are released from the orbital electrons of an atom: _(X)_ A. The energy is released in discrete packets or quanta. ____ B. The energy released is composed of all the wavelengths of the visible spectrum. ____ C. Both ____ D. Neither	

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Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{80}{100}$	1	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC II A CHAP 7 SEC II	
$\frac{90}{100}$	2	I,II,III,IV	Science-Chemistry UNIT V VB,D,1,2 Science-Physics UNIT X SEC 3	

Instructional Objectives Hierarchy	Criterion Test Measures

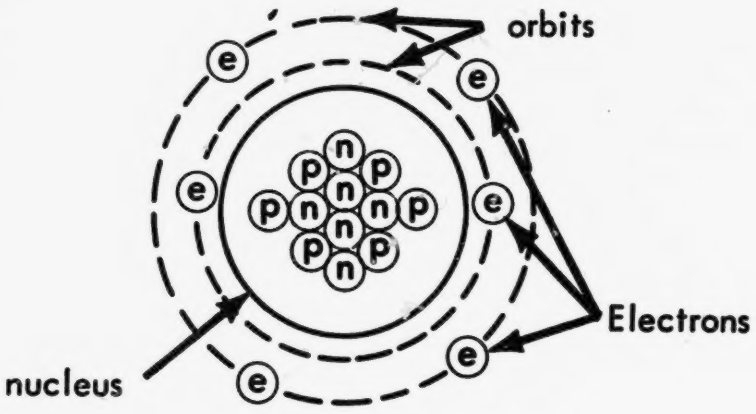
I.A.2 Present Concepts of Atomic Structure

1. Given the components of a carbon atom the learner can construct a diagram according to Bohr's postulate of an atom.

STIMULUS

A carbon atom contains 6 protons, 6 neutrons and 6 electrons. Draw a diagram of this atom according to Bohr's postulate of an atom.

RESPONSE



2. Given the terms neutron, electron and proton, the learner will be able to prepare a chart indicating the symbol and electrical charge for each particle.

STIMULUS

Complete the following chart by indicating the symbol and electrical charge for each of the particles:

RESPONSE

Particle	Symbol	Charge
Neutron	(n)	(0)
Electron	(e)	(-)
Proton	(p)	(+)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-8 TEXT A CHAP 10 SEC III A	
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC II B	

<table>
<tr><th>Instructional Objectives Hierarchy</th><th>Criterion Test Measures</th></tr>
<tr><td>3. Given a list of atomic particles the learner can prepare a list identifying mass relationships between neutrons, protons and electrons.</td><td>
<table>
<tr><th>STIMULUS</th><th></th><th>RESPONSE</th></tr>
<tr><td>Atomic Particle</td><td>Relative Mass</td><td></td></tr>
<tr><td>Neutron</td><td>____________</td><td>Approximately same mass as proton</td></tr>
<tr><td>Proton</td><td>____________</td><td>Approximately 2000 times an electron</td></tr>
<tr><td>Electron</td><td>____________</td><td>Approximately 1/2000 of a proton</td></tr>
</table>
</td></tr>
<tr><td>4. Given a series of statements relative to the structure of an atom the learner will be able to identify the factors which the structure of an atom determine.</td><td>The structure of an atom determines
_____ A. to which element it belongs
_____ B. the chemical properties of the element
__(X)__ Both
_____ Neither</td></tr>
<tr><td>5. Given a definition of ionization energy, the learner will be able to identify it as such.</td><td>
<table>
<tr><th>STIMULUS</th><th>RESPONSE</th></tr>
<tr><td>The energy required to separate an electron from the remainder of the atom is called the ____________ energy.</td><td>(ionization)</td></tr>
</table>
</td></tr>
</table>

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{95}{100}$	3	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC II B	
$\frac{90}{100}$	4	I,III	Science-8 TEXT B CHAP 4 SEC II A	
$\frac{90}{100}$	5	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC II B	

Instructional Objectives Hierarchy	Criterion Test Measures
6. Given a statement relative to binding energy, the learner will be able to identify that it holds the particles of the nucleus of the atoms together.	Binding energy is the term given to the force which _(X)_ A. holds the protons and neutrons together in the nucleus ____ B. holds the electrons in specific orbits ____ Both ____ Neither
7. Given the designation of a specific isotope of an element including the mass number and atomic number as sub and superscript, the learner will be able to identify the proper script which designates the atomic number and mass.	In the expression: $U \ ^{235}_{92}U$ ____ A. the superscript (235) is the atomic number ____ B. the subscript (92) is the atomic mass ____ Both _(X)_ Neither
8. Given a series of statements relative to atomic weight and atomic mass, the learner can identify the characteristics of each.	The atomic weight of an element ____ A. is the weighted mean of the masses of the neutral atoms of the isotopes that constitute the element ____ B. can differ slightly from the atomic mass number because of the presence of isotopes _(X)_ Both ____ Neither

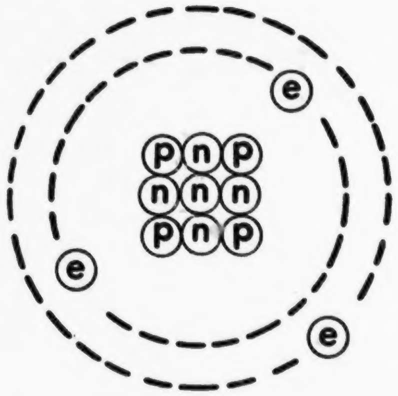
Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	6	IV	Science-Physics UNIT X Science-Chemistry UNIT V SEC V	
$\frac{90}{100}$	7	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC IV A2	
$\frac{90}{100}$	8	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC IV	

Instructional Objectives Hierarchy	Criterion Test Measures
9. Given a series of four choices, the learner can determine which choice determines the chemical properties of an atom.	The chemical properties of an atom are determined by (X) A. the number of electrons in the outer shell ____ B. atomic weight ____ Both ____ Neither
10. Given a description of the term "nuclide", the learner will be able to identify it as an atomic species characterized by the number of protons and neutrons it contains.	The term "Nuclide" is used to describe ____ A. both protons and neutrons (X) B. an atomic species characterized by the number of protons and neutrons it contains ____ Both ____ Neither
11. Given a definition of a nucleon, the learner will be able to identify that protons and neutrons are referred to as particles and nucleons.	Protons and neutrons are both called ____ A. Particles ____ B. Nucleons (X) Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	9	I,III	Science-BSB UNIT I SEC III Science-Chemistry UNIT VI SEC IV	
$\frac{90}{100}$	10	I,II,III,IV	Science-Chemistry UNIT V SEC III UNIT XI SEC IV	
$\frac{90}{100}$	11	I,II,III,IV	Science-Physics UNIT X SEC I Science-Chemistry UNIT V SEC III	

Instructional Objectives Hierarchy	Criterion Test Measures
12. Given two statements about atoms which differ only in their number of neutrons, identify that they will have a different mass and that they are called isotopes of the same element.	Two or more types of atoms which differ only in their number of neutrons ____ A. will have a different mass ____ B. are called isotopes of the same element (X) Both ____ Neither
13. Given a series of statements describing isotopes, the learner will identify that different isotopes of an element (1) possess same number of protons but varying numbers of neutrons and (2) are also considered as different nuclides.	Different isotopes ____ A. are Nuclides ____ B. have the same number of protons but varying numbers of neutrons (X) Both ____ Neither

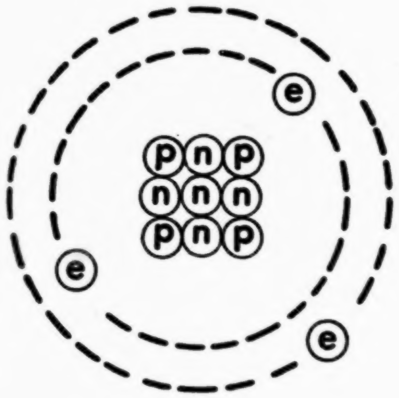
Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	12	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC IV B1	
$\frac{90}{100}$	12	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC IV B1	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
14. Given a diagram of an ion, the learner will be able to identify the particle as an ion and determine the net positive or negative electrical charge.		
	The atom shown would have a net (positive/ negative) electrical charge.	(positive)
	An atom (or molecule) with a net electrical charge is called a(n)____.	(ion)
	STIMULUS	RESPONSE
15. Given a description of the process whereby an electron is knocked away from an orbit, the learner will be able to state that this process is called ionization.	The process whereby an electron is knocked away from an orbit is called______________.	(ionization)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	14	I,II,III,IV	Science-Biology Science-Chemistry UNIT 6 SEC IV C Science-Biology UNIT 1 CHAP 3B	
$\frac{90}{100}$	15	I,II,III,IV	Science-Biology UNIT 1 CHAP 3B Science-Chemistry UNIT 6 SEC IV C	

Instructional Objectives Hierarchy	Criterion Test Measures
16. Given two statements about what produces similar behavior in elements, state that they have the same number of electrons in the outer shell.	The similar behavior among elements having similar chemical characteristics is attributed to the fact that: (X) A. they have the same number of electrons in the outer shell. ____ B. they have the same number of nucleons. ____ Both ____ Neither
17. Given six element symbols with superscripts, state that the superscript is called the mass number and that it represents the mass of the isotope to the nearest whole number.	STIMULUS RESPONSE ^{238}U ^{235}U ^{234}U ^{58}N ^{60}N ^{61}N The superscript in the element symbols shown above is called the ____________ number; it represents the mass of the ____________ to the nearest whole number. (mass) (isotope)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	16	I,III,IV	Science-Chemistry UNIT IV	
$\frac{90}{100}$	17	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC IV	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
18. Given a diagram of an atom, state the atomic mass number and the atomic number.	 The atomic number of Beryllium is _____; the atomic mass number would be about _____.	(4) (9)
	STIMULUS	RESPONSE
19. Given an example of the process of ionization, name the process as an ionization process and identify the resulting particle as an ion.	A gas bombarded by Gamma rays, wherein electrons are stripped off from the gas atoms by the Compton effect, (creating _______________) is an example of the _______________ process.	(ions) (ionization)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	18	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC II A	
$\frac{85}{100}$	19	I,II,III,IV	Science-Physics UNIT X SEC I	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
20. Given a description of periodicity, name it as such.	When elements are grouped in the order of increasing atomic weight, it is observed that certain physical and chemical properties are repeated; this phenomenon is referred to as the ______________ of the elements.	(periodicity)
	STIMULUS	RESPONSE
21. Given the Periodic Table, state: the atomic number of a given element; the atomic weight of a given element; the number of protons in the nucleus of a given element, an estimate of the number of neutrons; and the number of orbital electrons in a neutral atom of the element.	The Periodic Table of Elements	
	The atomic number of tin is ____	1. (50)
	The atomic weight of tin is ____	2. (118.70)
	How many protons are in the nucleus of carbon (C)?	3. (6)
	How many neutrons would you estimate to be in the nucleus of carbon (C)?	4. (6)
	How many electrons would a neutral atom of aluminum (Al) have?	5. (13)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{85}{100}$	20	I,III	Science-Biology UNIT II, III E 2 b Science-Chemistry UNIT VI	
$\frac{90}{100}$	21	I,III	Science-8 TEXT B CHAP 5 SEC II	

Instructional Objectives Hierarchy	Criterion Test Measures
22. Given two statements concerning the vertical arrangement of elements on the periodic chart, identify (1) the significance of the groupings and (2) the proper nomenclature.	Vertical arranged elements on the Periodic Chart: ____ A. are called "groups" ____ B. contain elements with analogous properties (X) Both ____ Neither
23. Given a graphic display, showing various forms of energy classified as to electromagnetic energy levels the learner can identify the display as a representation of the electromagnetic spectrum.	STIMULUS: A graphic display, showing the various forms of energy classified according to electromagnetic energy levels, is called an electromagnetic __________. RESPONSE: (spectrum)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	22	I,III	Science-Biology UNIT II, III E 26 Science-Chemistry UNIT 6	
$\frac{90}{100}$	23	I,II,III,IV	Science-8 TEXT B CHAP II	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
24. Given three explanatory statements about observed properties of matter state that all observed properties of matter can be explained if you assume a wave-particle characteristic of matter.	All observed properties of matter can be explained by (a) assuming that all matter exists in the form of particles (b) assuming that all matter exists in the form of waves (c) assuming a wave-particle characteristic of matter (d) none of the above	(c) assuming a wave-particle explanation of matter
25. Given two statements describing when a photon has mass, the learner can identify the relationship of movement to mass.	A photon has mass _(X)_ A. when it is moving ____ B. when it is not moving ____ Both ____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index		Media-Resource
$\frac{90}{100}$	24	I,II,III,IV	Science-Chemistry UNIT V SEC 5 E Science-Physics UNIT X, SEC 2 A UNIT X, SEC 3 B4		
$\frac{90}{100}$	25	I,II,III,IV	Science-Physics UNIT X SEC II E Science-Chemistry UNIT V SEC 5 B, 6, C		

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
26. Given a series of statements relative to mass and charge of various atomic particles, the learner will identify and classify each.	Match B-column terms to A-column terms	
27. Given a statement concerning the relationship between the kinetic energy and mass of a photon, the learner will be able to state that they are equivalent.	STIMULUS A photon is said to have mass because its kinetic energy is __________ to mass.	RESPONSE (equivalent)

Matching for item 26:

A-column	B-column	RESPONSE
	A. has mass of 1 amu	
1. proton	B. has no rest mass	1. (A, E)
2. electron	C. has mass of $\frac{1}{1800}$ amu	2. (C, D)
3. neutron	D. has negative electrical charge	3. (A, F)
	E. has positive electrical charge	
	F. has no electrical charge	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	26	I,II,III,IV	Science-8 TEXT B CHAP 4 SEC II A	
$\frac{90}{100}$	27	I,II,III,IV	Science-Chemistry UNIT V SEC 5, B, C, G Science-Physics UNIT X SEC II E	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
28. Given a series of statements, the learner will be able to identify the statements relevant to the law of conservation.	The law of conservation of energy states that energy (a) can be created but not destroyed (b) can be transformed into equivalent states (c) can neither be created nor destroyed (d) b and c are both correct (e) a and b are both correct	(d) both b and c are correct
	STIMULUS	RESPONSE
29. Given a statement about the type of energy that is produced by the changing of energy levels of orbital electrons within an atom, state that this type of energy is named electromagnetic energy.	The type of energy that is produced by the changing of energy levels of orbital electrons within an atom is called __________ energy.	(electromagnetic)
30. Given two correct statements concerning the reasons atoms may emit electromagnetic energy, state that both statements are correct.	Atoms may emit electromagnetic energy because ____ A. they are radioactive ____ B. they have absorbed a surplus of energy from some external source (X) Both ____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
90/100	28	I,II,III,IV	Science-8	
90/100	29	I,II,III,IV	Science-Chemistry UNIT V SEC V C Science-Physics UNIT IX SEC III	
90/100	30	I,II,III,IV	Science-Chemistry UNIT V SEC V C Science-Physics UNIT IX SEC III, C	

Instructional Objectives Hierarchy	Criterion Test Measures
I.B.1 Nuclear Radiation	
1. Given two forms of radiation, state that these are the forms of radiation radioactive elements give off.	In what form do radioactive elements give off radiation? ____ A. Alpha particles ____ B. Gamma Rays (X) Both ____ Neither
2. Given two statements about the forms of radiation, state that Beta particles are given off by radioactive elements.	In what form do radioactive elements give off radiation? (X) A. Beta Particles ____ B. Infrared Rays ____ Both ____ Neither
3. Given two correct statements describing when an element is radioactive, state that both of them are correct.	An element is radioactive ____ A. when it spontaneously disintegrates and gives off particles and/or electromagnetic energy. ____ B. when it randomly disintegrates and gives off particles and/or electromagnetic energy. (X) Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{95}{100}$	1	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III A	
$\frac{95}{100}$	2	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III A	
$\frac{95}{100}$	3	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. II B 1	

Instructional Objectives Hierarchy	Criterion Test Measures
I.B.2 Kinds of Nuclear Radiation—Properties	
1. The learner will be able to associate the fact that knowing the characteristics of a form of nuclear radiation or a nuclear particle, aids in predicting its effects on matter.	If you know the characteristics of a form of nuclear radiation or a nuclear particle, _(X)_ A. It will aid you in predicting its effect on matter ____ B. It will aid you in predicting the emitting element ____ Both ____ Neither
2. Given a series of statements about particles or rays, the learner will identify that different particles or rays will more easily penetrate matter because they have different abilities to ionize the atoms of which the matter is composed.	Different particles or rays ____ A. Will penetrate matter differently (i.e., some particles more than others). ____ B. Have different abilities to ionize the atoms of which the matter is composed. _(X)_ Both ____ Neither
3. Given a problem regarding the determination of an unknown isotope, the learner will be able to state that you must know the type of radiation emitted and the half-life in order to identify the isotope.	STIMULUS: If you know the type of radiation emitted by a radioactive isotope, you need only determine its __________ to identify it. RESPONSE: (half-life)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. II B 1	
$\frac{90}{100}$	2	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III A	
$\frac{90}{100}$	3	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III B	

Instructional Objectives Hierarchy	Criterion Test Measures: STIMULUS	RESPONSE
4. Given the definition of transmutation, the learner will be able to name it as such.	The changing of a nucleus from one element to another by the emission of radioactive particles is called ____________.	(transmutation)

5. Given three types of radiation—Alpha particle, Beta particle and Gamma ray, state their symbols and their compositions.

STIMULUS

SYMBOL	PROPER SYMBOL	TYPE OF RADIATION	PROPER COMPOSITION	COMPOSITION
α		Alpha-particle		1. electromagnetic wave
β		Beta-particle		2. 2 protons and 2 neutrons
γ		Gamma ray		3. an electron emitted from nucleus

RESPONSE

α	(Alpha particle)	2
β	(Beta particle)	3
γ	(Gamma ray)	1

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	4	I, II, III, IV	Science-8 TEXT B CHAP. 4 SEC. IV A 2	
$\frac{90}{100}$	5	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III A	

Instructional Objectives Hierarchy	Criterion Test Measures
6. Given a series of statements about the emission of gamma rays from the nucleus of a radioactive isotope, the learner will be able to identify that normally, before the nucleus will emit a gamma ray, it must emit an Alpha or Beta particle.	STIMULUS Normally, before the nucleus of a radioactive isotope will emit a gamma ray RESPONSE ____ A. It must emit an Alpha or Beta particle ____ B. It must absorb energy from some outside source ____ C. Both ____ D. Neither
7. Given that Alpha, Beta and Gamma rays are kinds of nuclear radiation, identify that protons and neutrons as types of radiation may also be emitted from the nucleus of radioactive atoms.	STIMULUS In addition to alpha, beta and gamma rays, the nuclei of radioactive atoms may sometimes emit ____ A. Protons ____ B. Neutrons ____ C. Infra red ____ D. Ultra violet ____ E. Both A and B ____ F. Both C and D RESPONSE

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index		Media-Resource
$\frac{90}{100}$	6	I, III	Science-Physics Science-Chemistry		
$\frac{90}{100}$	7	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III		

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
8. Given a statement about the approximate number of nuclear fragments discovered thus far, identify that almost 50 nuclear fragments have been discovered.	Scientists have discovered (almost 50/at most 5) nuclear fragments in their experimentation thus far.	(almost 50)
9. Given two terms—neutrino and meson—state that they are examples of particles identified from fragmentation of the nuclei of an atom.	An example of a particle identified from fragmentation of nuclei is ____ A. neutrino ____ B. meson (X) Both ____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	8	I, II, III, IV	Science-Physics UNIT X SEC. 1	
$\frac{90}{100}$	9	I, II, III, IV	Science-Physics UNIT X SEC. I	

Instructional Objectives Hierarchy	Criterion Test Measures
I.B.3. Characteristics of Radioactive Decay	
1. Given two statements, identify that the laws of probability enable you to determine the decay constant of an isotope when the sample of the isotope contains a great number of atoms.	The laws of probability ____ A. enable you to predict when a single atom will emit its radiation _(X)_ B. enable you to determine the decay constant of an isotope when the sample of the isotope contains a great number of atoms ____ Both ____ Neither
2. Given a statement about the relationship between the rate at which an isotope emits radiation and the amount of increase in the isotope present, state that the rate at which an isotope emits radiation increases as the amount of the isotope present increases.	STIMULUS The rate at which an isotope emits radiation (decreases/increases) as the amount of isotope present increases. RESPONSE (increases)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I, II, III, IV	Science-Biology UNIT VI CHAP. 1 B	
$\frac{90}{100}$	2	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	**RESPONSE**
3. Given instructions to write the definition of half-life, state that the half-life is the time required for a radioactive substance to lose half of its radioactivity.	Write a definition of half-life. ____________________ ____________________ ____________________	(Half-life is the time required for a radioactive substance to lose half its radioactivity.)
	STIMULUS	**RESPONSE**
(1) Given the half-life of a specific radioactive isotope, the learner will be able to state how long it would take for the amount of that isotope to be reduced by 1/4.	You are told that a radioactive isotope has a half-life of two years. How long would it take for a certain amount of this isotope to be reduced to 1/4 of this amount?	(2 half-lives or 4 years)
	STIMULUS	**RESPONSE**
(2) Given a graph of the rate of decay of a specific radioactive isotope, the learner will be able to state the half-life.	graph of rate of decay of 131_I Study this graph, compute the half life of the isotope, and place answer in box.	(8 days)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	3	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III B	
$\frac{90}{100}$	4	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III B	
$\frac{90}{100}$	5	I, II, III, IV	Science-Chemistry SEC. XI I C 2 Science-Physics UNIT X SEC. I	

1.B.4 Interaction of Radiation with Matter

1. Given a series of statements about the absorption of radiation by different materials of varying thickness, the learner will identify which materials are appropriate for shielding from the different types of radiation.

Experiments show that

____ A. A fairly great thickness of lead will absorb Gamma rays.

____ B. A sheet of paper is sufficient to absorb most Alpha particles.

(X) Both

____ Neither

A few inches of wood or aluminum is sufficient to absorb

(X) A. Beta particles

____ B. Gamma rays

____ Both

____ Neither

A sheet of paper is an example of the minimum amount of shielding required to absorb

____ A. Beta particles

____ B. Gamma rays

____ Both

(X) Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC III A 2	
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC III A 2	
$\frac{90}{100}$	3	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC III A 2	

Instructional Objectives Hierarchy

2. Given three types of radiation and three levels of penetration of matter, state that Alpha particles penetrate the least amount, Beta particles penetrate in between, and Gamma rays penetrate the farthest.

Criterion Test Measures

STIMULUS

Match the following:

Type of radiation	Ability to penetrate matter
____ A. Alpha-particles	1. penetrate least amount
____ B. Beta-particles	2. penetrate in between least and most
____ C. Gamma rays	3. penetrate. farthest

RESPONSE

(1 A.)
(2 B.)
(3 C.)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC III	

Instructional Objectives Hierarchy	Criterion Test Measures
3. Given three types of radiation, state that the Alpha particle is most effective in producing ions per unit path of material, that the Beta particles are in the middle in effectiveness in producing ions per unit path of materials, and that Gamma rays are the least effective in producing ions per unit path of material.	STIMULUS Match the following: Type of radiation: / Effectiveness in producing ions per unit path of material ____ A. Alpha particles — 1. least effective ____ B. Beta particles — 2. middle effectiveness ____ C. Gamma rays — 3. most effective RESPONSE (3 A.) (2 B.) (1 C.)
4. Given a statement which asks what effect of radiation on matter is of primary concern from a health standpoint, state that it is the ionizing effect.	STIMULUS From a health standpoint, the ________ effect of radiation on matter is of primary concern. RESPONSE (ionizing)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	3	I,II,III,IV	Science-Physics UNIT X SEC I - III	
$\frac{90}{100}$	4	I,II,III,IV	Science-Biology UNIT VI chap 3A	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
5. Given a statement about the ionizing effect of radiation on matter, (1) state that the atoms of the material absorb the energy of the radiation. (2) Identify that orbital electrons are ejected from the atom (3) state that what remains is a positively charged ion.	In the ionizing effect of radiation on matter, the atoms of the material absorb the ______________ of the radiation. (Orbital/ Nuclear) electrons are ejected from the atom; a positively-charged ______________ remains.	(energy) (Orbital) (ion)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum index	Media-Resource
$\frac{90}{100}$	5	I,II,III,IV	Science-Chemistry UNIT XI SEC 2 UNIT XI-4E 1, 2 Science-Physics	

I.C.1 Units of Measurement of Radioactivity and Radiation Dosimetry

1. Given four units for measuring radiation and radioactivity and four descriptions of these units, match the descriptions with their proper units.

STIMULUS

Match the units on the left with their descriptions on the right.

STIMULUS		RESPONSE
1. Rutherford	_____A. Roentgen equivalent man	(3 A.)
2. Roentgen	_____B. amount of radioactive material	(5 B.)
3. Rem	_____C. amount of radiation absorbed per gram of matter	(4 C.)
4. Rad	_____D. amount of radiation at a particular point at a specified distance from a source	(2 D.)
5. Curie		

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC II B2	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
2. Given instruction to write the symbol for a Curie and a Roentgen, write that "Ci" is the symbol for a Curie and that "r" is the symbol for a Roentgen.	Write the symbol for a Curie. _____	(Ci)
	STIMULUS	RESPONSE
	Write the symbol for a Roentgen. _____	(r)
3. Identify that it is sometimes useful to consider a Roentgen, a rad and a rem to be practically equivalent, although a Roentgen and a rad are not always equivalent.	Which of the following statements may usually be considered as fact? _____ A. Sometimes it is useful to consider a roentgen, a rad, and a rem practically equivalent. _____ B. A roentgen and a rad are not always equivalent. _(X)_ Both _____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC II B2	
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP & SEC II B2	
$\frac{90}{100}$	3	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC II B2	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
I.C.2 Prefixes and Symbols		
1. Given six prefixes—kilo, mega, micro, milli, nano, and pico—write the symbol for each of the prefixes.	Write the symbol for each of the following prefixes	
	____ Kilo	(K)
	____ Mega	(M)
	____ Micro	(µ)
	____ Milli	(m)
	____ Nano	(n)
	____ Pico	(p)
	STIMULUS	RESPONSE
2. Given six prefixes—kilo, mega, micro, milli, nano, and pico—order them from the largest to the smallest.	Order the following prefixes according to decreasing size; kilo, mega, micro, milli, nano, pico	(mega) (kilo) (milli) (micro) (nano) (pico)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-8	
$\frac{90}{100}$	2	I,II,III,IV	Science-8	

Instructional Objectives Hierarchy	Criterion Test Measures		
	STIMULUS		RESPONSE
3. Given eight units—curie, microcurie, picocurie, megacurie, roentgen, kiloroentgen, milliroentgen, and microroentgen—state that: 1. the milliroentgen is the most appropriate unit to measure the amount of background radiation; 2. the milliroentgen is the most appropriate unit to measure the amount of radiation from a chest X-ray; and 3. the picocurie is the most appropriate unit to measure the amount of 90 Sr found in milk.	_____A. Most appropriate unit to measure the amount of background radiation	1. curie	(7 A.)
	_____B. most appropriate unit to measure the amount of radiation from a chest X-ray	2. microcurie	(7 B.)
	_____C. most appropriate unit to measure the amount of 90 Sr found in milk	3. picocurie	(3 C.)
		4. megacurie	
		5. roentgen	
		6. kiloroentgen	
		7. milliroentgen	
		8. microroentgen	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	3	I,II,III,IV	Science-Biology UNIT VI SEC III C	

Instructional Objectives Hierarchy	Criterion Test Measures	
I.C.3 Minimum Detectable Weight		
	STIMULUS	RESPONSE
1. Given a statement about radioactive material and its ease of detection in comparison to an equal amount of chemical substance, state that a small amount of radioactive material is easier to detect.	A small amount of radioactive material is (easier/harder) to detect than an equal amount of chemical substance.	(easier)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC III	

Instructional Objectives Hierarchy	Criterion Test Measures	
I.C.4 Standards		
1. Given two correct statements about standards for measuring radioactivity, state that both are correct.	Standards for measuring radioactivity ____ A. are established and maintained by the National Bureau of Standards ____ B. are similar to the standards for measuring length, mass, and time (X) Both ____ Neither	
	STIMULUS	RESPONSE
2. Given a list of several instruments, identify those used to detect radiation.	Here is a list of instruments. Place a check before those used to detect radiation. ____ Accelerator ____ Reactor ____ Cloud chamber ____ Electroscope ____ Cathode-ray tube ____ Photographic film ____ Geiger tube ____ Scintillation detector	____ Accelerator ____ Reactor √ Cloud chamber √ Electroscope ____ Cathode-ray tube √ Photographic film √ Geiger tube √ Scintillation detector

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Social Science-8	
$\frac{80}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC III A	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
I.D. Methods of Detection and Measurement of Radioactivity		
1. State what is used to determine whether or not a radiation detection instrument is operating correctly.	To find out whether or not a radiation detection instrument is operating accurately, you compare its reading with the radiation of a ______________.	(known source or standard)
2. Identify what most radiation detection devices measure.	Most radiation detection devices measure _(X)_ A. the ionizing effect of radiation on matter ____ B. the degree of penetration of matter by radiation ____ Both ____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III A	
$\frac{90}{100}$	2	I, II, III IV	Science-Chemistry UNIT XI SEC 2 Science-Physics UNIT X	

Instructional Objectives Hierarchy	Criterion Test Measures
3. Given two correct responses about the function of mechanical and electrical devices used in radiation detectors, state that they are correct.	Radiation detectors are associated with mechanical and electrical devices. The function of these mechanical and electrical devices is ____ A. to amplify, convert, and record the signal from the detector ____ B. to supply high voltage to the detector when needed (X) Both ____ Neither
4. Given a statement about film being used to detect radiation, state what is the observable effect of radiation on photographic film and what process causes this effect.	STIMULUS — RESPONSE Film can be used to detect radiation. The radiation causes ________ in the film emulsion, resulting in chemical changes that will show up as ______ ______ when the film is developed. — (ionization) (dark areas)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	3	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. III A	
$\frac{90}{100}$	4	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. II B 1	

Instructional Objectives Hierarchy	Criterion Test Measures	
I.E.1 Sources of Radiation—Natural Sources		
	STIMULUS	RESPONSE
1. Given instruction to state the source of cosmic radiation, state that its source is outer space.	Cosmic radiation comes from ________________	(outer space)
	STIMULUS	RESPONSE
2. Given a statement about cosmic rays bombarding the earth, identify that the cosmic rays have always bombarded the earth.	To our knowledge cosmic rays have bombarded the earth (always/since about 1900).	(always)
	STIMULUS	RESPONSE
3. Given the statement concerning the three natural sources of background radiation, name the three natural sources of radiation.	We are always being exposed to radiation. The three natural sources of this background radiation are: 1. ________________, 2. radioactive isotopes in ________________, 3. radioactive isotopes in ________________.	1. (cosmic rays,) 2. (the ground (earth) and building materials,) 3. (our bodies and the bodies of those around us.)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-8 TEXT A CHAP 18	
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT A CHAP 18	
$\frac{90}{100}$	3	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC III	

4. Given four numbers, identify the appropriate amount of radiation we receive in a year from our natural background.

STIMULUS

Circle the number which most closely represents the amount of radiation received in a year from natural background.

3 mrad
300 mrad
300 rad
3,000 rad

RESPONSE

3 mrad
[✓ 300 mrad]
300 rad
3,000 rad

5. Given three sources of background radiation, identify the approximate amount of radiation contributed by each source.

STIMULUS

Place the appropriate letter in the second column of the box below.

A. 5 mrad/year
B. 25 mrad/year
C. 125 mrad/year
D. 5 rad/year
E. 25 rad/year
F. 125 rad/year

Source	Amount of Radiation Received from source in a year
Cosmic radiation	
Radiation from earth and building materials	
Internal radiation	

RESPONSE

(C)
(C)
(B)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	4	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC III	
$\frac{90}{100}$	5	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC III	

Instructional Objectives Hierarchy	Criterion Test Measures	
I.E.2 Fission and Fusion Process		
	STIMULUS	RESPONSE
1. Given the definitions of fission and fusion, distinguish between them.	(Fission/Fusion) is the joining together of small, light nuclei to form larger and heavier nuclei.	(Fusion)
	STIMULUS	RESPONSE
	(Fission/Fusion) is the splitting of large, heavy nuclei into primarily two fragments.	(Fission)
2. Given an example of fusion, the learner will be able to identify it as such.	The joining together of hydrogen nuclei to form helium is an example of _(X)_ A. fusion ____ B. fission ____ Both ____ Neither	
	STIMULUS	RESPONSE
3. Given a statement of why fission fragments are of concern to all of us, state that they are of concern because they are often highly radioactive.	Fission fragments are of interest and concern to all of us because they are (never/often highly) radioactive.	(often highly)

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Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC II	
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC II	
$\frac{90}{100}$	3	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC II A	

Instructional Objectives Hierarchy	Criterion Test Measures
4. Given two products in addition to the fission fragments which are released when a uranium nucleus splits, state that both are correct.	What other products are released when a uranium nucleus splits? ____ A. two to three neutrons per fission ____ B. energy (X) Both ____ Neither
5. Given two correct statements about mass being converted into energy which is released by nuclear fission and nuclear fusion, state that they are both correct.	Mass is converted into energy which is released in the process of ____ A. nuclear fission ____ B. nuclear fusion (X) Both ____ Neither
6. Given a statement about the magnitude of energy released during nuclear fission and the energy released in a normal chemical reaction, state that the energy released during nuclear fission is usually much greater than the energy released in a normal chemical reaction.	STIMULUS The energy released during nuclear fission is (much greater than/ equal to) the energy released in a normal chemical reaction. RESPONSE (much greater than)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	4	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC II A	
$\frac{90}{100}$	5	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC II	
$\frac{90}{100}$	6	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC II	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
7. Given instruction to construct a mathematical equation which expresses the basic law of the conversion of matter into energy, write the equation: $E = mc^2$	Write a mathematical equation which expresses the basic law of conversion of matter into energy.	($E = mc^2$)
	STIMULUS	RESPONSE
8. Given the description of the process which constitutes a chain reaction, name that process as a chain reaction.	Read the following description of a process. Process: A fissionable nucleus absorbs a neutron and fissions, releasing additional neutrons. The additional neutrons are absorbed by other fissionable nuclei, releasing still more neutrons, and so on. This process is called a(n) ____________________.	(chain reaction)
	STIMULUS	RESPONSE
9. Given a statement about critical mass and amounts of fissionable material, state that critical mass is the minimum amount of fissionable material that can sustain a chain reaction.	Critical mass is the (minimum/maximum) amount of fissionable material that can (sustain/stop) a chain reaction.	(minimum) (sustain)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	7	II, III, IV	Science-8 TEXT B CHAP 8 SEC II A1	
$\frac{90}{100}$	8	II, III, IV	Science-8 TEXT B CHAP 8 SEC II A1	
$\frac{90}{100}$	9	II, III, IV	Science-8 TEXT B CHAP 8 SEC III	

Instructional Objectives Hierarchy	Criterion Test Measures	
10. Given the statement that the amount of fissionable material less than a critical mass would not sustain a chain reaction, identify that the reason is that the neutrons can escape from the mass before being absorbed by other nuclei.	An amount of fissionable material less than a critical mass would not sustain a chain reaction because _(X)_ A. the neutrons can escape from the mass before being absorbed by other nuclei ____ B. no neutrons would be absorbed by other nuclei ____ Both ____ Neither	
	STIMULUS	RESPONSE
11. Given the phrase thermonuclear process, state that nuclear fusion is another name for thermonuclear process.	Thermonuclear process is another name for nuclear (fission/fusion).	(fusion)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	10	II,III,IV	Science-8 TEXT B CHAP 8 SEC III	
$\frac{90}{100}$	11	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC II B	

Instructional Objectives Hierarchy	Criterion Test Measures
12. Given two correct statements about the necessary conditions for fusion to occur, identify that: (a) extreme heat is necessary and that (b) extreme pressure is necessary for sustained fusion to occur.	In order for sustained fusion to occur there must be ____ A. extreme heat present ____ B. extreme pressure present (X) Both ____ Neither
13. Distinguish that an A-bomb utilizes the fission process and not the fusion process.	
14. Given a statement about atom bombs and the energy they yield, state that an A-bomb uses a fission process and that it yields energy that is equivalent to thousands of tons of TNT.	STIMULUS — RESPONSE An A-bomb uses a (fission/fusion) process, — (fission) and yields energy equivalent to (thousands/millions) of tons of TNT. — (thousands)
15. Given a statement about H-bombs and the amount of energy yielded, state that an H-bomb uses fusion and yields energy equivalent to millions of tons of TNT.	STIMULUS — RESPONSE An H-bomb uses (fission/fusion) process — (fusion) and yields energy equivalent to (thousands/millions) of tons of TNT. — (millions)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	12	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC IIB	
$\frac{90}{100}$	13 & 14	IV	Science-8 TEXT B CHAP 8 SEC III	
$\frac{90}{100}$	15	IV	Science-8 TEXT B CHAP 8 SEC IIB	

Instructional Objectives Hierarchy	Criterion Test Measures
16. Given a statement about heat and pressure required for fusion to occur in an H-bomb, identify that the heat and pressure required for fusion to occur in an H-bomb is supplied by an A-bomb.	The heat and pressure required for fusion to occur in an H-bomb is supplied by (X) A. an A-bomb ____ B. TNT ____ Both ____ Neither
	STIMULUS — RESPONSE
17. Given a statement about how nuclear explosions differ from conventional explosions, state that nuclear explosions are accompanied by radiation.	A nuclear explosion differs from a conventional explosion in that the nuclear detonation is accompanied by ____________. — (radiation)
18. Given two correct statements and three products of explosions, state that nuclear explosions and conventional explosions produce heat, blast effect and shock.	Heat, blast effect, and shock are the results of ____ A. nuclear explosions ____ B. Conventional explosions (X) Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	16	IV	Science-8 TEXT B CHAP 8 SEC IIB	
$\frac{90}{100}$	17	IV	Science-8 TEXT B CHAP 8 SEC II	
$\frac{90}{100}$	18	IV	Science-8 TEXT B CHAP 8 SEC II	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
19. Given two statements about nuclear technology and nuclear weapons, state that nuclear technology is primarily devoted to peaceful applications of nuclear energy, while nuclear weapons technology is primarily devoted to the development of destructive devices.	Nuclear technology is primarily devoted to ______________ application of nuclear energy.	(peaceful)
	Nuclear weapons technology is primarily devoted to the development of ______________ devices.	(destructive)
	STIMULUS	RESPONSE
20. Given a definition of fallout, state that it is such.	Fission fragments from the detonation of a nuclear device in the earth's atmosphere are trapped in condensed material which was vaporized in the intense heat. The particles which settle out of the atmosphere to the earth's surface are called ______________.	(fallout)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	19	IV	Science-8 TEXT B CHAP 8 SEC III	
$\frac{90}{100}$	20	III,IV	Science-8 TEXT B CHAP 7 SEC IV	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	**RESPONSE**
21. Given two statements about fallout, state which one describes immediate fallout and which one describes delayed fallout.	Fallout which settles out of the atmosphere in a few hours or days is called (delayed/immediate) fallout.	(immediate)
	STIMULUS	**RESPONSE**
	Fallout which takes years to settle back to earth is called (delayed/immediate) fallout.	(delayed)
	STIMULUS	**RESPONSE**
22. Given six amounts of fallout, identify the approximate amount from previous atomic tests which adds to our exposure from radiation background.	The approximate amount of fallout from previous atomic tests which is added to our exposure from background radiation is ______________. (Select one from A, B, C, D, E, or F) A. 1 to 5 mr per year B. 10 to 20 mr per year C. 100 to 200 mr per year D. 1 to 5 r per year E. 10 to 20 r per year F. 100 to 200 r per year	(B)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	21	III,IV	Science-8 TEXT B CHAP 7 SEC IV	
$\frac{90}{100}$	21	III,IV	Science-8 TEXT B CHAP 7 SEC IV	
$\frac{90}{100}$	22	III,IV	Science-8 TEXT B CHAP 7 SEC IV	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
23. Given a description of a government agency which checks fallout, name the agency.	Which government agency has the responsibility for continuously checking the amount of radioactive fallout? ________ ________ ________.	(Public Health Service)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	23	IV	Science-8 TEXT B CHAP 7 SEC IV	

Instructional Objectives Hierarchy	Criterion Test Measures	
I.E.3. Machine Sources of Radiation	STIMULUS	RESPONSE
1. Given a definition of an accelerator, name the term "accelerator" as best being described by the definition.	The general term used for a device that increases the velocity and energy of charged elementary particles such as electrons or protons, by the application of electrical and/or magnetic forces is a(n) ______________.	(accelerator)
	STIMULUS	RESPONSE
2. Given a list of instruments and devices, identify those which are accelerators.	Below is a list of instruments and devices. Circle the number next to those which are accelerators. 1. geiger counter 2. cyclotron 3. cosmotron 4. simulator ray tube 5. bevatron	1 geiger counter ② cyclotron ③ cosmotron 4 simulator ray tube ⑤ beavatron

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III	
$\frac{90}{100}$	2	II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III	

Instructional Objectives Hierarchy	Criterion Test Measures
3. Given two incorrect statements about the acceleration of subatomic particles, state that they are incorrect.	Subatomic particles are accelerated ____ A. in a straight path in a cyclotron ____ B. in a curved path in a linear accelerator ____ Both (X) Neither
	STIMULUS — RESPONSE
4. Given a statement about X-rays, identify that X-rays and Gamma rays are the same form of energy.	X-rays are (the same form/a different form) of energy as Gamma rays. — (the same form)
5. Given a correct statement about the origin of Gamma rays, identify that they come from the nucleus of the atom.	Normally, gamma rays come from the (X) A. nucleus of the atom ____ B. changing levels of orbital electrons ____ Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	3	II, III, IV	Science-Chemistry UNIT XI SEC. 4b Science-Physics UNIT X	
$\frac{90}{100}$	4	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. II B 1	
$\frac{90}{100}$	5	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. IIB	

Instructional Objectives Hierarchy	Criterion Test Measures
6. Given a correct statement about the origin of X-rays, identify that X-rays come from the changing levels of orbital electrons.	Normally, X-rays come from the ____ A. Nucleus of the atom (X) B. changing levels of orbital electrons ____ Both ____ Neither
7. Given two correct statements about the use of Gamma and X-rays to make pictures with photographic film, state that they are both correct.	____ A. X-rays can be used to make "X-ray pictures." ____ B. Gamma rays can be used to make pictures very similar to "X-ray pictures." (X) Both ____ Neither
8. Given two correct statements about hazards with Gamma rays and X-rays, state that they are both correct.	To avoid hazards, care should be taken with ____ A. Gamma rays ____ B. X-rays (X) Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	6	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. II B	
$\frac{90}{100}$	7	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. II B 1	
$\frac{90}{100}$	8	I, II, III, IV	Science-8 TEXT B CHAP. 7 SEC. II B 1	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
9. Given a description of a device, name the device to be a nuclear reactor.	A device used to control the release of energy from a fission process is called a(n) _________ _________.	(nuclear reactor)
	STIMULUS	RESPONSE
10. Given an incomplete statement about the three major uses of nuclear reactors, state the three major uses.	The three major uses of nuclear reactors are: 1. sources of _____________. 2. production of _____________. 3. as a tool for _____________.	1. (heat) 2. (neutrons) 3. (research)
11. Given two correct statements about fuel used in nuclear reactors, identify uranium and plutonium as the types of fuels used.	The type of fuel used in a nuclear reactor is ____ A. uranium ____ B. plutonium (X) Either ____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	9	I, II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III	
$\frac{90}{100}$	10	I, II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III	
$\frac{90}{100}$	11	I, II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III A 1	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
12. Given the function of the coolant in a nuclear reactor, name the coolant as the part of a nuclear reactor which performs that function.	The function of the ______________ in a reactor is to remove the heat which results from fission.	(coolant)
13. Given a correct statement that shielding is necessary to prevent radiation from escaping and injuring operating personnel, state that it is correct.	Shielding is necessary _____ A. for thermal insulation _(X)_ B. to prevent radiation from escaping and injuring operating personnel _____ Both _____ Neither	
14. Given two correct statements, identify both carbon, in the form of graphite, and water as common materials for a moderator.	_____ A. Carbon, in the form of graphite, is commonly used as a moderator. _____ B. Water is commonly used as a moderator. _(X)_ Both _____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	12	I, II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III A 2	
$\frac{90}{100}$	13	I, II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III A 2	
$\frac{90}{100}$	14	I, II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III A	

Instructional Objectives Hierarchy	Criterion Test Measures
15. Given the correct statement that heavy water is a common material used as a moderator, state that it is the correct answer.	A common material used as a moderator is ____ A. light water (X) B. heavy water ____ Both ____ Neither
16. Given two correct statements about the material used for control rods, identify both boron and cadmium as materials most commonly used for control rods in a nuclear reactor.	A material most commonly used for control rods is ____ A. boron ____ B. cadmium (X) Both ____ Neither
17. Given instructions to write the four examples of materials which are commonly used for shielding against radiation from a reactor, state any of the four including, lead, concrete, steel, dirt, air, and water.	STIMULUS Write four examples of materials that are commonly used for shielding against radiation from a reactor. 1. 2. 3. 4. RESPONSE (lead, concrete, steel, dirt, air, water)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	15	I, II, III, IV	Science-Chemistry UNIT XI SEC. 4 C 1, 2	
$\frac{90}{100}$	16	II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III A 1	
$\frac{90}{100}$	17	II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III A 2	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
18. Given a statement describing the differences between a nuclear reactor and a bomb, state that a nuclear reactor is unlike a bomb because the arrangment of the fissile materials is different.	A nuclear reactor is unlike a bomb because the ______________ of the fissile material is different.	(arrangement)
19. Given one correct statement about a nuclear power plant, identify it as a correct statement.	(X) A. A nuclear power plant can explode in ways similar to a conventional steam generating plant. ____ B. A nuclear reactor can explode like an atomic bomb. ____ Both ____ Neither	
20. Given a correct explanation of a precaution against steam explosion in a nuclear power plant, state that it is correct.	As a precaution for a steam explosion (X) A. A nuclear power plant must be surrounded by a containment sphere. ____ B. A conventional steam generator plant must be surrounded by a containment sphere. ____ Both ____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	18	II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III A 2	
$\frac{90}{100}$	19	II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III	
$\frac{90}{100}$	20	II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III	

Instructional Objectives Hierarchy	Criterion Test Measures
21. Given a correct statement about how fission products are released into the atmosphere, state that it is correct.	Fission products might be released into the atmosphere as the result of a steam explosion with a (X) A. nuclear power plant ____ B. conventional steam generator plant ____ Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	21	II, III, IV	Science-8 TEXT B CHAP. 8 SEC. III	

Instructional Objectives Hierarchy	Criterion Test Measures
II.A.1 Biological Effects of Radiation—Biochemical and Cellular Effects	
1. Given a statement about the effects of radiation, be able to describe what happens to living tissue, physically, when it is exposed to radiation of the various types.	Radiation has a more serious effect on growing embryos and children than on adult cells because ____ A. The adult cells are stronger phycially, and can resist the action of radiation better ____ B. Radiation can alter or hamper the growth process in young, active cells ____ Both ____ Neither
2. Given two correct statements concerning radiation effects, be able to describe what happens to living tissue when it is exposed to various types of radiation.	Radiation effects are ____ A. a direct effect of a particle striking a cellular structure and altering the structure ____ B. an indirect effect resulting from the formation of breakdown products _(X)_ Both ____ Neither
3. Given a statement about exposure to radiation, be able to describe what happens to living tissue when it is exposed to various types of radiation.	STIMULUS: Exposure to radiation other than ____________ cannot make one become radioactive. RESPONSE: (neutrons)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I, II, III, IV	Science-Biology UNIT 6 CHAP. 4 C	
$\frac{90}{100}$	2	I, II, III, IV	Science-Biology UNIT 6 CHAP. 4 C	
$\frac{90}{100}$	3	I, II, III, IV	Science-Biology UNIT 6 CHAP. 4 C	

Instructional Objectives Hierarchy	Criterion Test Measures
4. Relate the outward symptoms of radiation to the levels of radiation involved. 5. Given two correct statements about cells which are sensitive to radiation, state that they are correct.	Which of the following would contain cells that are particularly sensitive to radiation? ____ A. blood cells and the living layer of skin ____ B. growing embryos and children (X) Both ____ Neither
6. Relate the delayed and/or hidden effects or symptoms of radiation exposure to the levels of radiation involved. 7. Given two correct explanations of the cause of damage to living tissue, state that the explanation is correct.	Living tissue is damaged (X) A. at the instant of contact (immediately) ____ B. only if the exposure is prolonged ____ Both ____ Neither
8. Given two correct statements about considerations in subjecting a human being to radiation, state that both statements are correct.	In subjecting a human being to radiation one must consider ____ A. the value of the information to be gained ____ B. the amount of tissue damage which will result (X) Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	4 & 5	I, II, III, IV	Science-Biology UNIT 6 CHAP. 3 C	
$\frac{90}{100}$	6 & 7	I, II, III, IV	Science-Biology UNIT 6 CHAP. 2	
$\frac{90}{100}$	8	I, II, III, IV	Science-Biology CHAP. I A, b	

Instructional Objectives Hierarchy	Criterion Test Measures
9. Given two correct statements about the advisability of exposure to radiation through diagnostic X-rays, state that both statements are correct.	____ A. the amount of tissue damage associated with diagnostic X-rays is very small ____ B. a great deal of information is gained by the use of diagnostic X-rays. (X) Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	9	I, II, III, IV	Science-Biology CHAP. I A, b	

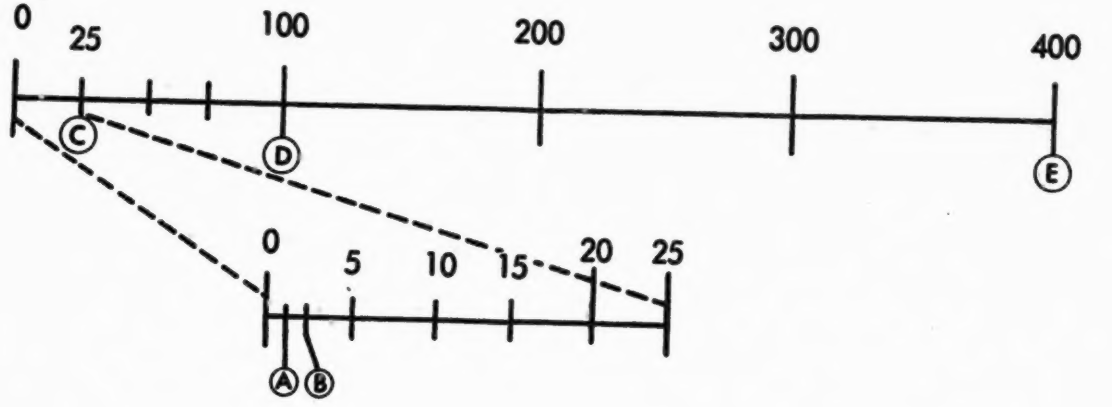
Instructional Objectives Hierarchy

10. Given a scale of levels of radiation the learner will be able to:

1. Name the approximate levels of radiation for visible symptoms of radiation; 2. Lethal level of radiation; 3. The level to cause serious radiation sickness; 4. Approximate amount of naturally received background radiation yearly; 5. Approximate amount of radiation received in diagnostic X-rays.

Criterion Test Measures

STIMULUS:



Place the letter from the scale above beside the statement which is appropriate to that level of radiation.

1. _____ the approximate amount of whole body radiation (single dose) which would cause detectable symptoms of radiation sickness
2. _____ a lethal level of radiation
3. _____ would cause serious radiation sickness
4. _____ approximate amount of naturally received background radiation per year
5. _____ approximate amount of radiation received in the usual diagnostic X-ray

RESPONSE

1. (C)
2. (E)
3. (D)
4. (A)
5. (A)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	10	I, II, III, IV	Science-Biology UNIT 6 CHAP. I E UNIT 8 CHAP. II CHAP. 3 A, B, C	

Instructional Objectives Hierarchy	Criterion Test Measures
	STIMULUS RESPONSE
11. Given a statement about the types of cells most sensitive to radiation damage, the student will identify rapidly dividing cells.	The types of cells most sensitive to radiation damage are: a. bone cells and brain cells a b. rapidly dividing cells ⓑ c. liver cells and kidney cells c d. none of the above d
12. Given a statement about the types of cells particularly sensitive to radiation, the student will name, cancer cells.	Which of the following would contain cells that are particularly sensitive to radiation? _____ A. liver, kidney and muscle of adult (X) B. cancer _____ Both _____ Neither
13. Given a statement about the effects of exposing living tissue to radiation, the student will be able to identify that the effects may not show up immediately and that key molecules that control the activities of cells are ionized.	When living tissue is exposed to significant radiation _____ A. the effects may not show up immediately _____ B. key molecules that control the activities of cells are ionized (X) Both _____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	11	I, II, III, IV	Science-Biology UNIT 7 CHAP. 2, B, C, D UNIT 7 CHAP. 3 UNIT 7 CHAP. 4	
$\frac{90}{100}$	12	I, II, III, IV	Science-Biology UNIT VII CHAP. V	
$\frac{90}{100}$	13	I, II, III, IV	Science-Biology UNIT VI CHAP. 3 A, C	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
14. Given a statement about the level of radiation below which tissue damage will not occur, the student will be able to identify that it is not yet known.	Circle one of the numbers below.	
	The level of radiation below which tissue damage will not occur is	
	1. 1 rad	1
	2. 25r of whole body radiation	2
	3. not yet know	[✓ 3]
	4. there is no minimum level, below which damage will not occur.	4
	STIMULUS	RESPONSE
15. Given a statement about the symptoms after radiation exposure, state that if symptoms do not appear, one cannot be sure that damage did not occur.	If symptoms do not appear after radiation exposure, one (can/cannot) be sure that damage did not occur.	(cannot)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	14	I, II, III IV	Science-Biology UNIT VI CHAP. 3, A, C	
$\frac{90}{100}$	15	I, II, III, IV	Science-Biology UNIT VI CHAP. 3 A, C	

Instructional Objectives Hierarchy

16. Given a statement about the early effects of massive doses of radiation, identify them as: (1) nausea, (2) loss of appetite, (3) rupture of blood vessels in digestive organs, (4) will show up in a matter of a few weeks, (5) skin reddening, (6) loss of white blood cells, (7) high possibility of internal infection.

17. Given a statement about the possible delayed effects of massive doses of radiation, identify them as (1) bone diseases, (2) may not be apparent, (3) leukemia, (4) tumors, (5) mutations.

Criterion Test Measures

STIMULUS

Place the appropriate B-Column numbers in the space below the A-Column statements:

A-Column

Early effects of massive doses of radiation

I.

Possible delayed effects of massive doses of radiation

II.

B-Column

1. nausea
2. bone diseases
3. may not be apparent
4. •loss of red blood cells
5. loss of appetite
6. rupture of blood vessels in digestive organs
7. dizziness
8. will show-up in a matter of a few weeks
9. skin reddening
10. leukemia
11. tumors
12. loss of white blood cells
13. loss of vision
14. high possibility of internal infection
15. mutations
16. loss of hearing

RESPONSE

I. 1, 5, 6, 8, 9, 12, 14

II. 2, 3, 10, 11, 15

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	16 & 17	I, III, IV	Science-Biology UNIT VII CHAP. IV A CHAP. V A	

Instructional Objectives Hierarchy	Criterion Test Measures
II.B.1 Radiation Genetics—Mutation	
1. Given statements about the genetic damage due to radiation, state that (1) it occurs only when the mutation is to reproductive cells, (2) it more often results in slight effects than in marked effects.	Genetic damage due to radiation: ____ A. occurs only when the mutation is to reproductive cells ____ B. occasionally results in slight effects and almost never in marked effects (such as the creation of a monstrosity) (X) Both ____ Neither
2. Given two incorrect statements about reoccurance of mutations in the children of the individual who has a defect, state that both statements are incorrect.	If mutations occur, the defect will definitely appear in the children of the individual if: ____ A. the mutation occurs in a reproductive cell ____ B. the mutations occur in a cell other than a reproductive cell ____ Both (X) Neither
3. Given a statement about mutations, state that a mutation is a change or alteration in the heredity characteristics of an individual.	STIMULUS: Mutation is a change or alteration in the ____________ characteristics of an individual. RESPONSE: (heredity)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	II,III,IV	Science-Biology UNIT VI CHAP 3 A,1	
$\frac{90}{100}$	2	II,III,IV	Science-Biology UNIT VI CHAP 3 A	
$\frac{90}{100}$	3	II,III,IV	Science-Biology UNIT 6 CHAP 3 A,1	

Instructional Objectives Hierarchy	Criterion Test Measures
4. Given statements about mutations, identify that mutations appear as malfunctions of the inner physiological process of the body chemistry.	Mutations are: ____ A. readily detectable within the individual in whom they occur (X) B. appear as malfunctions of the inner—physiological process of the body chemistry ____ Both ____ Neither
5. Given statements about mutation occurence in a reproductive cell, identify that if a mutation occurs in a reproductive cell (1) the fact may remain hidden for many generations, (2) the fact cannot be detected in the individual.	If a mutation occurs in a reproductive cell, the fact: • ____ A. may remain hidden for many generations ____ B. cannot be detected in the individual (X) Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	4	II,III,IV	Science-Biology UNIT 6 CHAP 3,D	
$\frac{90}{100}$	5	II,III,IV	Science-Biology UNIT 6 CHAP 3,D	

Instructional Objectives Hierarchy	Criterion Test Measures	
II.C Radiation Safety	STIMULUS	RESPONSE
1. Given statements about the safe handling of radioactive materials, name the three major variables that control the degree of exposure to which the individual is exposed.	In the safe handling of radioactive materials, the three major factors of concern are: 1. limit to ______________ of exposure 2. adequate ______________ from source 3. use of proper ______________	 (time) (distance) (shielding)
2. Given statements about increasing distance from radioactive material by three times, determine by applying the inverse square law, the decrease in radiation as one moves away from the source.	If you increase your distance from radioactive material by three times, you will: _____ A. receive three times the amount of radiation _____ B. receive about nine times less radiation _____ Both _____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC III	
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC IV	

Instructional Objectives Hierarchy

II.C.2 Shielding

1. Given a list of materials and a list of the types of radiation, identify in terms of the density of material, the amount of shielding required for each type of radiation.

Criterion Test Measures

STIMULUS

Match the materials in Column B with the type of radiation (in Column A) for which each would provide (minimum) adequate shielding.

Column A

a) Alpha particles ______________

b) Beta particles ______________

c) Gamma rays ______________

d) X-rays ______________

Column B

1. sheet aluminum
2. plastic
3. sheet of paper
4. thick lead sheets
5. wood

RESPONSE

a) (3)

b) (1, 2, 5)

c) (4)

d) (4)

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-Chemistry UNIT XI SEC 4 C,1,2, 4 E,1 Science-Physics UNIT X	

Instructional Objectives Hierarchy	Criterion Test Measures	
	STIMULUS	RESPONSE
II.C.3 Decontamination		
1. Given a definition of decontamination, name the definition as such.	________________ consists of removing all radioactive contaminants from the surfaces of equipment by cleaning and washing and disposing of the contaminant in a safe location; this is extremely important to the safe handling of radioactive materials.	(Decontamination)

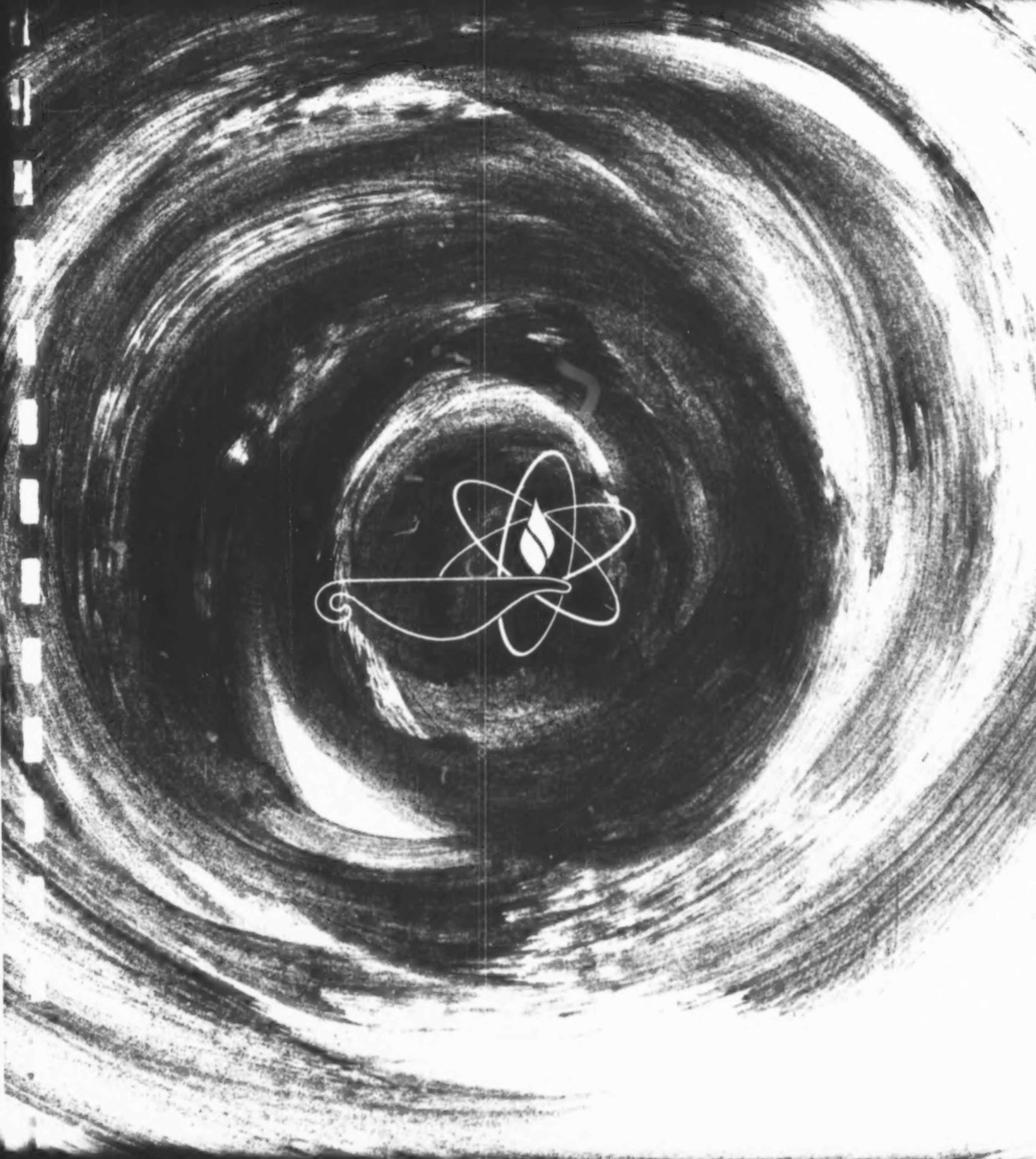
Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
90/100	1	I,II,III,IV	Science-8 TEXT B CHAP 8 SEC III A2	

Instructional Objectives Hierarchy	Criterion Test Measures
II.C.4 Disposal of Radioactive Wastes	
1. Given statements about the disposal of long-lived radioactive material, identify that disposal of long-lived radioactive material is a major problem and is accomplished by burial in underground tanks and in containers buried at sea.	The disposal of long-lived radioactive waste material is ____ A. not a major problem (X) B. accomplished by burial in underground tanks and in containers buried at sea ____ Both ____ Neither
2. Given statements about Alpha particles, identify that Alpha particles require a minimum of shielding and also present a particular hazard to the human body if ingested or inhaled.	Alpha particles ____ A. require a minimum of shielding ____ B. present a particular hazard to the human body of internal radiation if ingested or inhaled (X) Both ____ Neither

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Social Science-8	
$\frac{90}{100}$	2	I,II,III,IV	Science-8 TEXT B CHAP 7 SEC III A	

Instructional Objectives Hierarchy	Criterion Test Measures	
II.C.5 Entrance of Fission Products into Human Body	STIMULUS	RESPONSE
1. Given a statement about the characteristics of behavior of radioactive isotopes, state that once a radioactive isotope is free in nature, it will become concentrated in unpredictable locations.	Once a radioactive isotope is free in nature they will become concentrated in (predictable/unpredictable) locations.	(unpredictable)
	STIMULUS	RESPONSE
2. Given a statement about the characteristics of behavior and the dangers of radioactive isotopes state that the human body cannot distinguish radioactive from non-radioactive isotopes and so will metabolize them in the same way.	The human body (can/cannot) distinguish radioactive from non-radioactive isotopes and so will metabolize them in the same way.	(cannot)
3. Given a statement about the concentration of radioactive isotopes in the body, state that (1) iodine is apt to be concentrated by the thyroid gland, (2) strontium is apt to be concentrated in the bones and teeth.	Different radioactive isotopes are apt to be concentrated in the body in accordance with the chemicals which have similar properties. For example: ____ A. Iodine is apt to be concentrated by the thyroid gland ____ B. Strontium is apt to be concentrated in the bones and teeth _(X)_ Both ____ Neither	

Recommended Achievement	Objectives Measured	Framework Index	Curriculum Index	Media-Resource
$\frac{90}{100}$	1	I,II,III,IV	Science-Biology UNIT I CHAP 3,B	
$\frac{90}{100}$	2	I,II,III,IV	Science-Biology CHAP 3,B	
$\frac{90}{100}$	3	I,II,III,IV	Science-Biology CHAP 3,B	



NUCLEAR SCIENCE CONTENT

Content	Level of Understanding
I. Background Concepts in Nuclear Energy	
A. Atomic Structure	Be able to give a brief quantitative description of the historical development of the atomic concept.
1. Historical Development	
a. Democritus—300 B.C.: together with his teacher Leucippus, founded a Greek school of thought which taught that all material things were made up of small indivisible units which Democritus called "atoma" (= "indivisible").	Identification of a specific person with his contribution is of secondary importance.
b. Dalton—1808: developed atomic theory to explain certain observable phenomena; first quantitative measurements to explain theory; laid foundation for later work.	Memorization of specific dates unnecessary.
c. Thompson—1897: the electron as a constituent of matter; measured ratio of change to mass for electron.	
d. Rutherford—1911: from experiments postulated the existence of a nucleus in the atom.	
e. Planck—1901: first to postulate quantum theory.	
f. Bohr—1913: proposed the idea of permissible orbits and the release of energy when an electron drops to a lower state.	

Content	Level of Understanding
2. **Present Concepts of Atomic Structures**	
a. Nucleus composed of: symbol charge neutrons n o protons p +	Be able to describe or diagram a Bohr atom. Name the particles of which the atom is composed. Describe where they are located in the atom. Know their charge and relative mass.
b. Orbital	
Energy levels, binding energy, ionization potential	Develop concepts of size of and space within,the atom.
c. Terms and symbols	Understand how the structure of the atom determines to which element it belongs and also determines the chemical properties of the element.
symbol (1) Mass number A (superscript) (2) Atomic number Z (superscript) (3) Definitions of nucleon, nuclide, isotope, ion, ionization	Use the periodic chart by being able to differentiate between atomic number and atomic weight, and use them to determine numbers of protons, neutrons and electrons in atoms of different elements.
d. Periodicity of the elements	Reason for and significance of the arrangement of the elements in families.
e. Electromagnetic radiation spectrum, photons	Quantum nature of orbital electron energy levels.
	Particle - wave duality of matter.
	Recognize the common forms of electro-magnetic energy.
	Understand that the only difference between the various forms of electromagnetic energy is in their wave length or frequency, and that the higher the frequency, the greater the energy (Energy = hf).
	Be aware of the use of experimental evidence to support concepts of atomic structure and energy levels.

Content	Level of Understanding
B. Nuclear Radiation	
1. Historical Development	To discern the interrelations of scientific discoveries and their contribution to each other in advancing our understanding of the atom.
a. Roentgen—1895: discovery of X-rays	
b. Becquerel—1896: discovery of radioactivity	Know that contribution and development to present understanding of nuclear science is international.
c. Marie and Pierre Curie—1898: announced discovery of two new radioactive elements, polonium and radium	
d. Rutherford: determined that radiation was composed of Alpha and Beta rays while Curie and Villard determined that radiation was composed of Gamma rays.	
2. Kinds of Nuclear Radiation—Properties	
symbol	
a. Alpha particles	Composition and charge of each particle or ray and the implications for range of penetration, ability to ionize, and for radiation dosimetry.
b. Beta particles Negatrons or Positrons or	
c. Gamma rays	Make student aware of existence.
d. Neutrons	
e. Protons	

Content	Level of Understanding
f. Sub-nuclear particles: Neutrino Exotic particles: Mesons, etc.	Recognize that physicists discovered almost 50 nuclear fragments in their experimentations. No satisfactory unifying concept postulated.
I. B. 3. Characteristics of Radioactive Decay	
a. Constancy of type and energy of emitted radiation.	Individual property of each isotope. Understand the nuclear transformation associated with each emission.
(1) Continuous energy distribution spectrum for Beta decay	Be able to trace transmutations.
b. Constancy of rate of disintegration.	Know that each specie has its own negative interest rate. (Compare with interest rate determination on loans.) Be aware that we can compute the interest rate for each isotope and determine a decay constant for each specie. Develop understanding of the concept of half-life as a convenient scientific tool. Memorization of definitions of half-life. Be able to compute half-life from graphic representation of data and by use of decay constant.
4. Interaction of Radiation with Matter	
a. Specific ionization (1) Heavy charged (2) Electrons (3) X- and Gamma rays	Know relative effectiveness of each to produce ions and the implications to degree of damage and degree of penetration.

Content	Level of Understanding
b. Processes by which energy from X- and Gamma radiation is absorbed by matter (1) Photoelectric effect (2) Compton collisions (3) Pair production	Understand process and implications. Memorization of specific terms of secondary value.
C. Units of Measurement of Radioactivity and Radiation Dosimetry	
1. Basic Units — Symbol a. Curie — Ci b. Roentgen c. Rad — Rad d. Rem — Rem	Know what the units measure, how they are used, and the reasons why one measure is preferable to another in a given situation. Specific memorization of definitions not required.
2. Prefixes — Symbol a. Milli — m b. Micro c. Nano — n d. Pico — p	Comparison between common amounts of radioactive material encountered, and also between amount of radiation received from various sources should be included. Should also include relative biological effect and M.P.D.
3. Minimum Detectable Weight a. Proportional to half-life and mass number.	Absolute figures can be used to make comparison between sensitivity of detecting radiation and chemical analysis. Several useful analogies.
4. Standards a. Use in instrument calibration and nuclear medicine	Radiation standards similar to standards established for other units of measure. They are controlled by the National Bureau of Standards, and by the use of relatively simple techniques, comparisons can be made with these standards so that dose rates can be accurately determined.

Content	Level of Understanding
D. Methods of Detection and Measurement of Radioactivity	
1. Specific Detection Techniques	
a. Detectors (1) Electroscope (2) Photographic emulsions (film badge) (3) Cloud Chamber (4) Bubble Chamber (5) Ionization Chamber (6) Proportional Counters (7) Geiger Muller Tubes (8) Scintillation Detector (a) Solid (b) Liquid	General concept that all detectors depend on the effect of the radiation, primarily ionization, on matter. The associated "block boxes" contain the mechanical and electronic devices to amplify, convert and record by various devices the signal from the detector and to supply high voltage to the detector when needed. Some detail about the operation of film, a geiger tube, and a scintillation detector Recognize the names of the other common detectors and recorders. To identify information re: atomic energy which if dispersed to the public might dispel their fears.
b. Recorders (1) Scalers (2) Ratemeters (3) Pulse Height Analyzers (4) Medical Scanners and Cameras (5) Total Body Counters	
E. Sources of Radiation	
1. Natural Sources	
a. Cosmic radiation - 125 mrad/yr.	Define cosmic radiation as radiation coming from outer space.
b. From the earth and building materials - 125 mrad/yr.	The amounts from these sources should be quantized in order to make meaningful comparisons.

Content	Level of Understanding
c. Internal radiation - 25 mrad/year.	
2. Fission and Fusion Process	Describe the liquid drop model of fission. Formation of fission products, themselves, often highly radioactive.
a. Process, products, energy released	Understand that the loss of mass and the release of energy is far greater than that which is released from normal chemical reactions, and the fact that several neutrons are released per fission.
	Provides an application for Einstein's equation.
b. Maintaining a chain reaction	Basic requirements of a chain reaction: an initial source of neutrons; fissile atoms; and a moderator to slow down fast neutrons.
c. Conditions for criticality	Student should be able to recite conditions for criticality: fuel mass and geometry that allow criticality to be attained.
d. Fusion	Compare and contrast fission and fusion.
	Recognize that nuclear energy can be used to trigger fusion of light elements into heavier ones (e.g., Helium).
e. Nuclear Weapons	How they work; what are the dangers: heat, blast, shock, as well as radiation.
	Comparison between conventional explosions and a nuclear detonation.
(1) Historical development of nuclear energy (2) Wartime considerations (3) Post-war developments (4) Growth of limited wars	To differentiate between nuclear technology and nuclear weapons technology. To identify arguments for the development and utilization of nuclear weapon systems and strategies connected with them. To identify the influence of nuclear weapons on international politics.

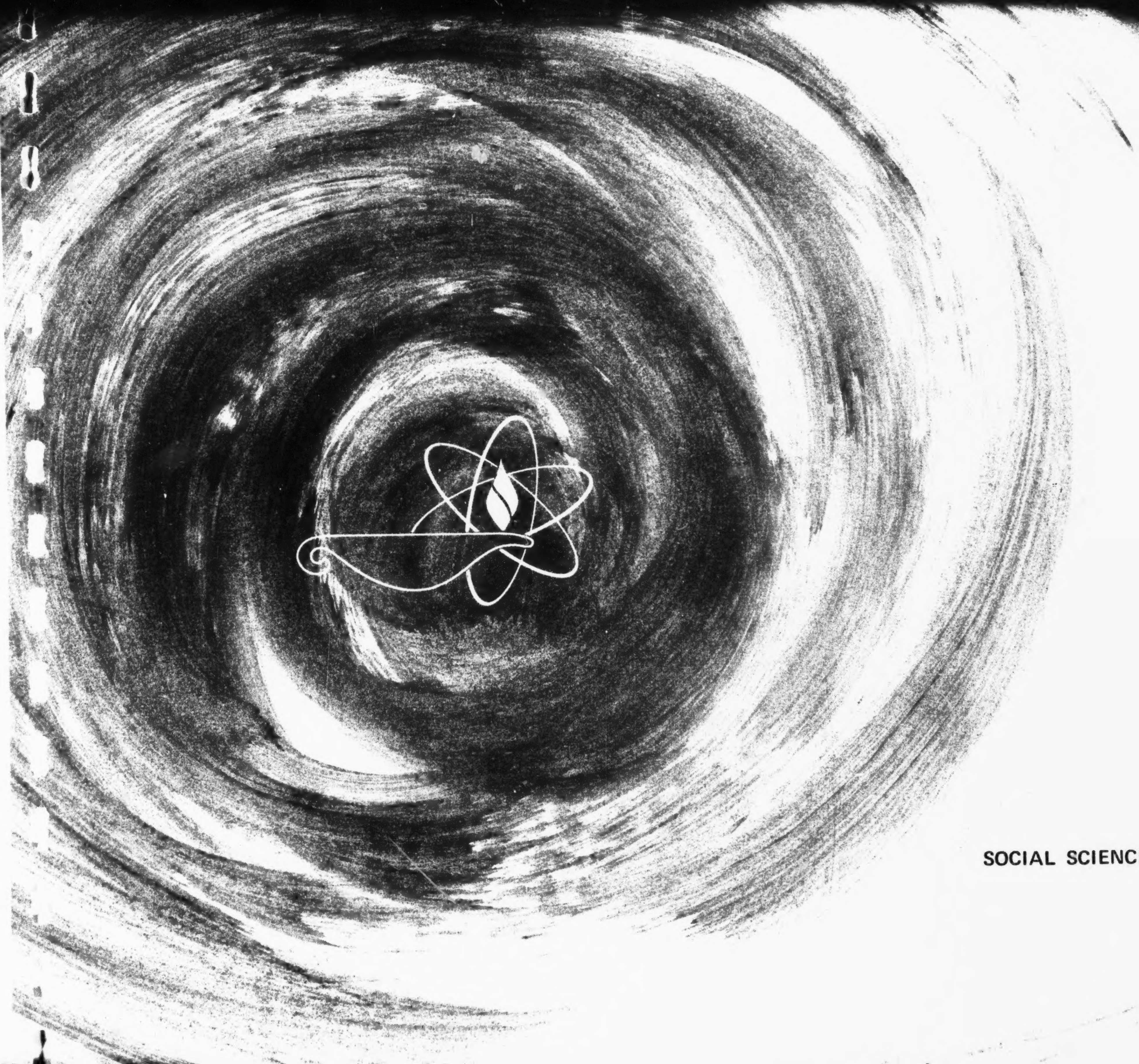
Content	Level of Understanding
(5) Growth of detente between the Soviet Union and the USA	
(a) Treaties (proliferation, test ban, etc.)	
(b) Other	
(6) The balance of terror notion.	
f. Fallout	Need to know potential dangers; ingestion, uptake with food; external exposure. Translate fallout into exposure - U.N. Report 1962-1964. Constant check at centers for radiation measurement by Public Health Service.
I. E. 3. Machine Sources of Radiation	
a. Accelerators	Should understand basic concept: that electric or magnetic field exerts a force on a charged particle and therefore can be used to accelerate them to high velocity and energy. Recognize the names of various types of accelerators.
b. X-ray machines	X-ray machines produce energy that is essentially the same as Gamma rays. Therefore, their use must receive the same consideration and care to avoid hazard.
c. Nuclear reactors	Devices to control the release of energy from the fission process. How and why they are unlike a "bomb." Their use as sources of heat energy, production of neutrons, and as a research tool. In a general way, know the major parts of a reactor and what they do.
d. Reactors may explode	To identify the fears of the public regarding atomic energy.

Content	Level of Understanding
c. Internal radiation - 25 mrad/year.	
2. Fission and Fusion Process	Describe the liquid drop model of fission. Formation of fission products, themselves, often highly radioactive.
a. Process, products, energy released	Understand that the loss of mass and the release of energy is far greater than that which is released from normal chemical reactions, and the fact that several neutrons are released per fission.
	Provides an application for Einstein's equation.
b. Maintaining a chain reaction	Basic requirements of a chain reaction: an initial source of neutrons; fissile atoms; and a moderator to slow down fast neutrons.
c. Conditions for criticality	Student should be able to recite conditions for criticality: fuel mass and geometry that allow criticality to be attained.
d. Fusion	Compare and contrast fission and fusion.
	Recognize that nuclear energy can be used to trigger fusion of light elements into heavier ones (e.g., Helium).
e. Nuclear Weapons	How they work; what are the dangers: heat, blast, shock, as well as radiation.
	Comparison between conventional explosions and a nuclear detonation.
(1) Historical development of nuclear energy (2) Wartime considerations (3) Post-war developments (4) Growth of limited wars	To differentiate between nuclear technology and nuclear weapons technology. To identify arguments for the development and utilization of nuclear weapon systems and strategies connected with them. To identify the influence of nuclear weapons on international politics.

Content	Level of Understanding
II. Biological Effects of Radiation The Committee made a few suggestions relative to content in this area. Because of this we have supplemented those specific statements previously noted with what seems to us appropriate understanding. Your reactions regarding accuracy, relevancy, level and completeness are invited.	
A. Biochemical and Cellular Effects	
1. Damage a. Ionizing effects early - delayed	The damage to living tissue by radiation is caused primarily by the ionizing effect of the radiation on key molecules that control the activities of the cell. The damage occurs at the instant of radiation, but the damage may take a long time to show itself.
(1) Individual awareness of the dangers and advantages of the use of radiation and radio-active materials.	To identify medical needs of the population.
b. Somatic damage	It is not yet known whether there is or is not a threshold below which somatic damage would not occur. The decision to subject any human to radiation must be arrived at after evaluation of the relative hazard compared with the value of the information gained.
c. Low-level	For low levels of radiation such as might be involved with diagnostic X-rays, the damage is so slight that the information gained is of greater value than the slight additional hazard.

Content	Level of Understanding
d. Early	Exposure to radiation other than neutrons cannot make one become radioactive. Damage from ionizing radiation can be classified into early and delayed effects. Early effects will show up within a matter of a couple of weeks. Delayed effects may not be apparent for many years.
e. Delayed	Some of the early effects include skin reddening; nausea, followed by loss of appetite; rupture of blood vessels in the digestive organs; loss of white cells from the blood; and a high possibility of internal infection Delayed effects include an increase in the possibility of leukemia, bone diseases, tumors and mutations.
f. Dosimetry	Idea of amount of radiation required to produce above symptoms, along with a comparison with background and amount of radiation medically applied.
g. Sensitivity	Cells most sensitive to damage are rapidly dividing cells, i.e., growing embryos, children, the living layer of skin, cancer, etc. Lower forms of life can survive much higher doses of radiation than humans can survive. (Examples.)
II. B. Radiation Genetics	
1. Mutation	
a. Cause of mutation	Radiation damage that causes mutation that can be handed down to succeeding generations can occur only if the individual's reproductive cells are radiated.
b. Identification	Mutation of genes cannot be identified from any examination of the exposed individual.
c. Degree of mutation	Genetic damage may remain hidden for many generations.

Content	Level of Understanding
	Most mutations appear as malfunctions of the inner physiological processes of the body chemistry which cannot be detected without special study.
	Mutations resulting in slight effects are more common than those with marked effects.
II. C. Radiation Safety	
1. Principles of Safe Handling of Radioactive Materials	
a. Protection	Understand three major factors of protection from radiation: time of exposure, distance from source, use of shielding.
b. Inverse square law	Application of inverse square law.
2. Shielding	Different kinds of radiation require a different choice of shielding material. (Ex.)
3. Decontamination	Essentially careful cleaning up and getting rid of radioactive material.
II. C. 4. Disposal of Radioactive Wastes	Identify problem and ways to cope with it. Continuous research effort going on to deal with problem. To identify some disadvantages associated with the use of nuclear energy.
5. Entrance of Fission Products into Human Body	
a. Transfer of radioactive material through food chains.	Particular hazard of internal radiation from alpha particles. Significance of half-life and method of metabolizing. (Ex.) Concentration of some specific isotopes. Distribution of isotopes difficult to predict once they are free in nature.



SOCIAL SCIENCE CONTENT

SOCIAL SCIENCE DATA BANK

On the basis of the module shown in a previous section, several other social studies modules could be developed to demonstrate the social impact of nuclear technology. What follows is a compendium of basic need-to-know data relative to various social issues and/or problems. No attempt was made to be exhaustive, only illustrative and extrapolations regarding future political, social and economic changes were kept as tightly constrained by the empirical data as was possible.

The categorization technique employed for arranging the data is simply to identify significant areas of need and of change or potential change, and the role that would be played by nuclear technology. In the left hand column were placed the items of greatest concern, as identified by the social science consultants and Project staff. In the right hand column are the need-to-know data relative to each need, concern, or issue. More detailed information regarding specific content can be gained by consulting the Bibliography.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
AIR POLLUTION	Air pollution is caused in part by contaminants coming from the burning of fossil fuels in power plants as a result of the exhaust system utilized in burning the fuel. Nuclear energy does not employ the same means of producing heat to generate steam for power purposes and thus does not produce air pollutants in any significant amounts. Nuclear energy, therefore, will help to alleviate the problem of air pollution when utilized in urban areas.
WATER NEEDS	As the population grows (estimated at 320,000,000 by 2000 in the U.S.A.), the demand for fresh water will grow tremendously. Nuclear energy is now being used and will continue to be used to desalinate sea water and thus produce abundant supplies of fresh water for all potential uses in the future. Desalination through nuclear means will be a great asset to those areas of the U.S.A. and underdeveloped world which have arid or semi-arid conditions. Desalinization will allow for greater population and industrial dispersion and thus help to alleviate population problems.
FOOD NEEDS	As the population grows, the demand for food will also increase. Nuclear science and technology are developing techniques to improve the quality and quantity of food. These techniques include, *inter alia*, pasteurization and sterilization processes, controlled mutations for crop improvement, insect and weed control, prevention of decay.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
POWER NEEDS	The traditional energy sources in the U.S.A. have been fossil fuels. These fuels are being rapidly depleted as the power demands of our country expand; this in turn creates the need for searching for new sources of power. The major new source of power is nuclear energy which rests on a raw materials base which is relatively abundant and which will, when breeder reactors have been perfected, become almost limitless. Factors which illustrate this general statement follow A high standard of living depends upon the power that is available to a country. Little power usually means an underdeveloped economic system and a low standard of living. Exploitation of all sources of power, then, becomes necessary if the U.S.A. is to maintain its standard of living. Current reserves of fossil fuels will be exhausted in 200 years with those most easily mined gone in 100 years. (estimated) Energy consumption in the U.S.A. doubles every ten years. America's need for power has been growing at an average rate of four percent over the last decade and with population growth and continued industrial expansion, this power needs growth will continue at a faster rate. U.S. population is growing at a constant rate of 1.7% per year from 1900-1967 and while some leveling off is to be expected, it is also expected that the U.S.A. will have a population of over 320,000,000 by the year 2000. (estimated)

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
POWER NEEDS (Continued)	Nuclear power has certain advantages over traditional fuels overall costs of generation of electricity are equal to and potentially cheaper than electricity generated by fossil fuels raw materials for nuclear fuel will last at least 1700 years and will be limitless when breeder reactors have been perfected use of nuclear power as an energy source in industrial areas will help to lessen air pollution since pollutants from reactors is insignificant utilization of nuclear power will allow for industrial and population dispersal since new areas can be opened and/or industry will no longer be constrained by power needs fossil fuel prices will go down as nuclear power gains wider use Nuclear reactors are already in use in the U.S.A. to generate power and have added greatly to American power capacity and have demonstrated their great safety

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
POWER NEEDS (Continued)	The development of nuclear power sources in the underdeveloped world is one of the most necessary actions for those nations since most of them lack traditional power sources and often lack even fossil fuels. nuclear power can more easily be located nuclear power can open new living areas and therefore reduce population pressures in traditional areas nuclear power in the long run is cheaper than fossil fuels which will allow for the generation of additional investment capital to be utilized for other purposes for economic growth

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
INDUSTRIAL NEEDS	Radioactive isotopes are currently being utilized to improve the quality and increase the quantity of industrial products and processes Isotopes called tracers are used to trace the flow of liquids in closed containers (e.g., pipes) to help determine trouble spots Isotopes are also being used to measure the thickness of various products to insure higher quality: pipes, newsprint, textiles, and so forth Radioisotopes are also used to judge the wearing capabilities
URBAN AREA NEEDS	Cities are becoming increasingly congested, which develops a number of social problems which affect health: traffic, slums, pollution, etc. A nuclear powered society will allow for industrial and population dispersal since neither industry nor populations will need to concentrate around fuel supplies or power sources Dispersal will help to eliminate pollution and relieve other urban problems Nuclear power can provide water and power for habitation in areas previously considered uninhabitable Nuclear power can provide for more suitable living environments within cities and residences

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
FOREIGN POLICY AND NATIONAL SECURITY NEEDS	Nuclear weapons have had a great impact on American and World Society. They are still controversial with arguments which oppose and support development and use of nuclear weapons.
	A. Those in favor maintain, inter alia, the following position
	Weapons of such destruction help to deter aggressors from attacking since they will fear atomic annihilation
	Nuclear weapons are needed to balance the manpower preponderance of our potential enemies
	Threat of nuclear war limits potential enemies' freedom of action on a global scale
	Maintenance of weapons superiority gives the U.S.A. an opportunity for greater freedom of action vis-à-vis potential enemies
	Weapons superiority makes it more likely, and believable to potential enemies, that the U.S.A. will be able to not only destroy potential enemy weapons but also to threaten his cities
	B. Those opposing maintain, inter alia, the following position
	Nuclear weapons are so powerful that in the event of war no victor could emerge; only civilization be destroyed

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
FOREIGN POLICY AND NATIONAL SECURITY NEEDS (Continued)	Spread of nuclear weapons will allow lesser powers to practice nuclear coercion
	Nuclear weapons do not deter war but lead to different forms of war (e.g., limited war, insurrections)
	Accidental war could come about through escalation
	Nuclear weapons tend to maintain attitudes of fear and mistrust of intentions which could lead to a misinterpretation of acts which in turn could lead to nuclear war
	Whatever the pro and con arguments, nuclear weapons have had a profound effect on foreign policy
	Fear of mutual destruction has developed a balance of terror which appears to mitigate the use of atomic bombs and has given rise to new forms of war: limited wars, guerilla war, insurrections, etc.
	Fear of mutual destruction has also lead to a number of treaties aimed at lessening the rivalry in nuclear weaponry a test-ban treaty between the U.S.A. and Soviet Union which stated that neither side would conduct atmospheric tests of atomic weapons thus reducing the radioactive contamination of air and soil; also signed by other nuclear powers at the time (not France or the People's Republic of China)

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
FOREIGN POLICY AND NATIONAL SECURITY NEEDS (Continued)	a nuclear non-proliferation treaty in which the major powers (except France and the People's Republic of China) agreed not to share their nuclear capabilities with non-nuclear powers a treaty which bans the military use of atomic power in outer space
POLITICAL TRENDS RELATIVE TO TECHNOLOGICAL INNOVATION	The traditional governmental pattern of the U.S.A. is rapidly changing. In place of the many foci of power and decision making, governmental and non-governmental, there is arising a centralized administrative source of power. Major decision making now rests with the Administrative Branch of the Federal Government. Congress has neither the funds nor the expertise to compete in influence with the Administration. Professional bureaucrats have developed such expertise that communication between the Administration and Congress regarding technical questions is exceedingly difficult. Expenditures for research and development and therefore the direction of technological change rests at the moment in the hands of the Administration. In terms of nuclear technology and innovation which exemplifies these developments, the Government has established a body called The Atomic Energy Commission which is an agency independent of Congress or any other agency of the Federal Government. Its members are appointed, with the consent of Congress, by the President, and the AEC is directly responsible to the executive. It has its own corps of experts and carries on research into the military, medical, agricultural and industrial application of nuclear energy. It also makes decisions regarding the funding of basic research in the nuclear field. In terms

POLITICAL TRENDS RELATIVE TO TECHNOLOGICAL INNOVATION (Continued)

of its control over other areas of the society, it has the power to declare certain information secret and may control any information given to the public as it sees fit. It has the power to license and control use of atomic sources, regulate, inspect, and so forth, all that is connected with the development of atomic energy. The AEC is an example of how the Government is moving into areas traditionally thought of as outside the prerogatives of government: e.g., the AEC funds the building of power plants, hires university scholars for special projects, determines prices for radioactive materials, regulates industries, and even establishes semi-private industries as watch dogs (e.g., Sandia Corporation); all of these things conflict with the traditional notion that government should stay out of business and let the system operate as it will.

With this growing power of agencies connected with the Administrative Branch of the Government, we also see the development of controlled news issued to the public and Congress upon which decisions would or could be made regarding developments in nuclear techology and science. Thus, Congress is losing power in relationship to the Executive Branch; the public cannot determine what is occurring and is thus losing its ability to vote wisely; and bureaucrats are making basic decisions once reserved for elected officials. The relationship between governments, then, at all levels and with industry and the academic community has changed. The fundamental prerogative for the development and control of atomic energy rests with the Administrative Branch of the Federal Government and while it has shared to an extent control with state governments which demonstrate their capacity to take on regulatory responsibility, the basic decision to involve or not to involve state governments rests with the Federal Government. Another indicator of growing centralization is the apparent growth of regional planning, industrial-political interlocking cooperation and diminution of intellectual independence.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
POLITICAL TRENDS RELATIVE TO TECHNOLOGICAL INNOVATION (Continued)	Interstate agreements are developing to aid states incapable of carrying on expensive programs in nuclear energy by themselves and also to face up to interstate problems (such as water pollution) arising from the utilization of nuclear energy. The funding of research by the Federal Government in the field of nuclear energy has made a number of scholars and universities heavily dependent on federal funds to carry on their activities which in turn makes these traditional sources of independent inquiry more receptive to the demands of the Government. Industry too has a new special relationship with the Federal Government. In its drive to acquire more or a larger share of federal money, interlocking jobs are arising whereby personnel from industry become employed by the Government and where governmental workers become employed by private industry when it is in the interest of both the Government and industry. Industry is also growing larger and multi-based industries (those with many products and services) are growing to capitalize on the multiple needs of government. Because the Government is spending such huge sums, industry is also becoming more influenced and directed by the decisions of government. Thus, the influence of government at the national level on other governments, industry and the academic community has grown so great that the Federal Government has extraordinary power to affect the direction of technological change and is using that power on the basis of national interest as defined by the people in the Administrative Branch. Defining the national interest is a difficult task for those in government. Apparently, it has decided that social problems (race, housing, smog, etc.) are becoming too complex and too expensive to be solved on the local level. These problems, then, are becoming nationalized and more and more controlled by the Federal Government. Military or defense needs have also added to the growth of decision making power of the Federal Government as well as the decision of the recent administrations that the Federal Government had to insure the continuous and smooth growth of the economy. In addition to the growth of federal power, there are other phenomena to show the increasing

POLITICAL TRENDS RELATIVE TO TECHNOLOGICAL INNOVATION (Continued)

centralization of decision making in the U.S.A.: local and state governments are finding it necessary to develop their own bureaucracies to cope with their relationship with the Federal Government and technological change generally: there is increasing cooperation and ties between government and business and universities in an effort to find solutions to pressing national problems. These things mean, then, that the pressure of technological change, among other things, has caused a decisive change in the nature of and role of government which makes individual involvement that much more difficult. The essential problem for the individual is: how does he devise means by which to affect decisions.

Although the expansion of the Administrative Branch of the Federal Government in the area of decision making vis-à-vis technological developments is clear, there are also signs that decentralization tendencies are developing which could be important for the individual in a technological society and which could be profitably pursued by educators concerned with individualism in a technological-bureaucratic state. These tendencies include: Regional planning among contiguous states, growing decision making within state bureaucracies, inter-agency cooperation, and competition between governmental (at all levels) agencies, industrial interests, and educational institutions, increased concern by articulate individuals with the imperatives of technological society.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
ECONOMIC TRENDS RELATIVE TO TECHNOLOGICAL INNOVATIONS	Under the impact of technological change, the traditional market mechanisms (i.e., supply-demand balance, open competition, etc.) in this country are rapidly changing, especially in those industries having close ties with the government. Businesses' relationship with government has changed from the traditional pattern of no governmental interference, to a cooperative arrangement whereby business is given a free hand to carry out tasks defined by the government as essential. Governmental contracts are written on a cost plus basis which means that the Government is taking the risks and that competition is being reduced since one contractor is utilized rather than open competition and many businesses being involved. This phenomenon arose primarily from the Government's military needs and from the fact that R & D expenditures for the kinds of products and systems needed by the Government are much too expensive for any single business to afford, thus the Government spends more on R & D than all other sources combined. The expenditures of R & D by the Federal Government means that it has a much greater impact on economic decision making than heretofore. As a result the public and private sector of the economy are growing closer and closer together. Another outgrowth of government involvement in business has been the rise of the supercorporation which is capable of handling the multiple demand of the Government and the consequent decline in smaller corporations. Thus there is a continued move toward bigness in government and business. Businesses are attempting to rationalize their operations and thus again there is a shift from ownership power to manager and professional power. Organization has now become one of the greater formers of individual opinion and values.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
ECONOMIC TRENDS RELATIVE TO TECHNOLOGICAL INNOVATIONS (Continued)	The process of technological change is no longer the result of spontaneous market forces but is the deliberate creation of public and quasi-public efforts. Because technological change is a conscious effort, it is capable of being controlled and directed. Because there is a drive for higher standard of living and constant economic growth that has involved business, government and universities, an informal cooperative group among the bureaucrats of each institution has formed to maintain in the U.S.A. a permanent technological revolution. To maintain growth and innovation, the Federal Government has established a number of non-profit, semi-private businesses for which the Government puts up the money for a business that pretty much runs itself free from traditional intragovernmental constraints (i.e., bureaucracies, civil service, rules, etc.). This development of semi-private corporations is largely a result of nuclear technology since the first one was established by the AEC, the Sandia Corporation, to supervise the many developmental projects sponsored by the AEC. Since then another fifteen corporations have been established by the Federal Government. Thus it is that often private corporations without responsibility to the public are making decisions which have a great effect on the public. Thus technological change has produced not only big government but also big industry, both of which are remote from individual decision making.
SOCIAL TRENDS RELATIVE TO TECHNOLOGICAL INNOVATIONS	The lives of individuals in America will be affected by the political and economic changes described above. There will be less individual influence on political and economic decision making — but perhaps collections of individuals will have a decisive effect — and the individual will increasingly find himself connected with large, impersonal organizations. In terms of the impact of technology the following trends seem evident: morality and ethics will become more personalized; technology will mean not only liberation from work but liberation for work in the sense that work will be newly defined as creative,

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
SOCIAL TRENDS RELATIVE TO TECHNOLOGICAL INNOVATIONS (Continued)	artistic, mind-freeing activity; there will be less privacy with the development of computer information storage banks utilized by government and business. Social problems will at first become more intense: air and water pollution will worsen, cities will continue to degenerate, traffic and population pressures will continue to accelerate, welfare needs will continue to grow, new occupations will develop calling for increased and different educational systems, and so on. Many of these social problems can be affected by nuclear technology. All of the pessimistic views are supported by fairly secure data investigated by social scientists. The objective for an instructional system is to make the student aware of the trend and then to devise means by which the learner citizen can gain some sense of personal identity.
ORGANIZATIONS CONCERNED WITH NUCLEAR TECHNOLOGY	UNITED STATES GOVERNMENT Joint Committee on Atomic Energy This committee is made up of members from both houses of Congress. Its responsibility lies primarily in the development of basic legislation regarding the development and control of nuclear technology. Through its hearings it helps to clarify issues, problems and proposals relative to nuclear technology. It publishes transcripts of hearings and annual reports which may be obtained from the Government Printing Office.

ORGANIZATIONS CONCERNED WITH NUCLEAR TECHNOLOGY
(Continued)

Atomic Energy Commission, U.S.A.

This agency is an independent agency of the Federal Government. It does not fall under the jurisdiction of any traditional department made up of a board appointed by the President. Its responsibilities include the development of nuclear technology through providing research and development funds and identifying areas of need; developing atomic weapons research; controlling or regulating the use of nuclear energy in its many applications; licensing; considering and solving problems associated with atomic energy such as site problems, waste disposal, transfer of radioactive materials, etc. It is the single most powerful agency in the United States concerned with nuclear energy. It publishes numerous books, pamphlets and other materials which can easily be obtained from them by writing.

Department of Labor

This department determines health and welfare standards for workers connected with nuclear energy or radiation and has an apprentice program for developing worker skills needed by industries utilizing nuclear energy. Reports are published and available.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY

RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA

ORGANIZATIONS CONCERNED WITH NUCLEAR TECHNOLOGY
(Continued)

Department of Health, Education and Welfare

This department's Food and Drug Administration investigates and maintains standards for public health regarding the use of radioactive materials when involved with processing or treating foods from the farm to the container. It also develops policies regarding the use of radiation techniques in the food industry. This department also has a children's bureau which is especially concerned with the effects of radiation on children. Reports are published and available.

Department of Commerce

The department's Bureau of Standards establishes standards concerned with permissible dosages of radiation and means of measuring radiation. This department also is concerned with the packaging of radioactive materials to make them safer to handle. Reports are published.

Department of Agriculture

This department carries on experimental programs on the use of radiation techniques for the improvement of plants, insect control, and similar things. It also establishes standards for workers involved with radioactive materials in agriculture. Publishes reports.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
ORGANIZATIONS CONCERNED WITH NUCLEAR TECHNOLOGY (Continued)	Interstate Commerce Commission The commission is responsible for establishing controls on the interstate transportation of radioactive materials. Other Agencies Atomic Industrial Forum This group is made up primarily of business-associated scientists and managers. It is concerned primarily with the dissemination of information regarding the industrial use of nuclear energy and to act as a pressure group for the further development of atomic energy. Publishes reports. American Nuclear Society This society is made up of university, business and government nuclear scientists. The society is interested in dissemination of information relative to significant new ideas and application of atomic energy. Publishes magazines and annual reports.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
ORGANIZATIONS CONCERNED WITH NUCLEAR TECHNOLOGY (Continued)	Power Companies Most power companies in the U.S.A. now have some direct or indirect concern with the development of atomic power plants. They publish reports and other materials which generally support the full use of nuclear power through private companies and to assuage fears related to atomic energy. Edison Electric Institute - an association of private electric power companies It publishes reports for laymen which demonstrate the advances made by private industry in the development and utilization of nuclear energy. Inter-American Nuclear Energy Commission An agency of the organization of American states responsible for inter-American cooperation in peaceful nuclear fields.

ORGANIZATIONS CONCERNED WITH NUCLEAR TECHNOLOGY
(Continued)

INTERNATIONAL

Atomic Energy Commission

This agency is made up of an international team of of experts in nuclear science and technology. The agency is primarily an information gathering and dissemination agency on the relationship of nuclear energy and technology to world problems. They also have many technical journals and publications which are available from the United Nations.

Atomic Energy Authority, United Kingdom

This agency is responsible for furthering the development of nuclear technology in the United Kingdom and for the safety of nuclear applications. Publishes reports.

EURATOM

European agency overlapping but more inclusive than the European Economic Community working for the Europe-wide development of nuclear energy.

SOCIAL, ECONOMIC, AND POLITICAL TRENDS, ISSUES AND PROBLEMS RELATIVE TO NUCLEAR TECHNOLOGY	RELEVANT NEED-TO-KNOW SOCIAL SCIENCE DATA
ORGANIZATIONS CONCERNED WITH NUCLEAR TECHNOLOGY (Continued)	International Atomic Energy Agency Located in Vienna, Austria, this agency supports research, teaching and other developmental aspects of nuclear technology. The IAEA is a major organization associated with the United Nations involved in the international cooperation on the peaceful exploitation of nuclear technology.